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STUDY OF A SINGLE DOSE ^{131}I - ^{126}I RATIO IN DAIRY COWS

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ABSTRACT

Four groups of two lactating Holstein cows each were dosed in a single ingestion experiment with four different combinations of ^{126}I and ^{131}I ranging from 0 to 20.1% ^{126}I. Theoretical equations developed and experimental results indicate that it is possible to detect and quantitate ^{126}I in the presence of ^{131}I in milk samples by determining the physical half-life of the combined radioiodines from repetitive gamma scans on the same samples---even though the individual gamma energies of ^{126}I and ^{131}I cannot be resolved by the gamma analysis system. Peak levels of the radioiodines in milk from all cows were observed at five hours (first milking) after oral ingestion of dose. Subsequently, milk exhibited an effective half-life (T_{eff}) ranging from 12.5 to 18.0 hours with an average value of 14.4 hours. Calf thyroid percent uptake from ingestion of milk contaminated with radioiodine ranged from 8.4 to 13.2% with an average of 11.15%. The T_{eff} in calf thyroids ranged from 5.74 to 9.55 days with an average of 7.46 days. The recoveries of radioiodine from milk by use of ion-exchange column and AgI precipitation methods, when compared to gamma scans of whole milk, had large standard deviations indicating further experimentation with these methods is desirable prior to field use.

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INTRODUCTION

Any study of radioiodine dosimetry must necessarily include consideration of all possible radioactive iodines. Of the radioiodines of intermediate half-life, the ^{126}I isotope with a half-life of 13.2 days has generally been ignored. Though not a significant fission product, ^{126}I can be formed by (γ,n) and (n,2n) reactions with stable iodine. The principal gamma energy produced in the decay of this isotope appears quite close to that of ^{131}I in gamma spectrometric analysis. For most gamma analysis systems it is not possible to resolve the different peaks. Thus, the principal method of detection of ^{126}I in the presence of ^{131}I, is by half-life determination. The closeness of their half-lives makes the latter method a tedious procedure. Because of this, if ^{126}I were associated with ^{131}I in any contaminant, it would probably be reported as ^{131}I. If ^{126}I is present in a contamination situation, its longer half-life would increase the thyroid dose.

This study was conducted to achieve these objectives:

1. To develop analytical techniques for detection of ^{126}I in the presence of ^{131}I in milk;
2. To determine the variation with time of ^{126}I - ^{131}I levels in milk from cows given a single ingestion dose of these iodines mixed in various proportions;
3. To determine calf thyroid uptake from ingestion of milk obtained under objective 2; and
4. To compare the results from AgI precipitation and ion exchange separation methods with gamma spectrometry results.

PROCEDURE

A. Dose Preparation

Iodine-131 as NaI (carrier free)* was transferred to five ml of water in a volumetric flask to which was added a slight amount of ethyl alcohol. Iodine-126 (carrier free)** as NaI was treated in a like manner. Total activity was determined by gamma scan for each of the ^{131}I and ^{126}I isotopes before and after the dosages were prepared. Different activity level capsules were prepared for the cows. (Table 1.)

B. Animal Husbandry

Eight mature, lactating Holstein cows were divided into four groups of two cows each. One cow in each group was a high producer so there would be sufficient milk for both calf feeding and counting, the other four cows were closely matched for daily milk output. The groupings and physiological data on the cows are shown in Appendices A and B. The calculated dose to be administered to each cow was pipetted into a size 000 gelatin capsule which was then placed inside a lubricated 1 oz. gelatin capsule. By means of a balling gun, the capsule was placed on the roof of each cow's tongue, so that immediate deglutition occurred. This insured that no contents were spilled before entering the rumen. A swipe of each cow's muzzle was made within 30 minutes following administration. Results of these swipes are given in Appendix C.

The experimental animals remained with the rest of the milking herd and were milked and fed in a normal manner.

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*^{131}I was obtained from Iso/Serve, Inc., 131 Portland St., Cambridge Massachusetts

**^{126}I was obtained from General Atomic, San Diego 12, California Stable iodine (1.3g) was irradiated by a 25 MeV linear accelerator for one hour.

Table 1. Activity levels administered to cows on Aug. 11, 1965

Group	Cow	Time	^{131}I		^{126}I		Total		131 %	^{126}I %
			ml	µCi	ml	µCi	ml	µCi		
I	15	0955	0.225	95.6	0.600	24	0.825	119.6	79.9	20.1
	27	1025								
II	21	1000	0.250	106.2	0.400	16	0.650	122.2	86.9	13.1
	19	1010								
III	25	0950	0.250	106.2	0.200	8	0.450	114.2	93.0	7.0
	18	1020								
IV	28	0945	0.275	116.8	0	0	0.275	116.8	100.0	0
	12	1005								

Stock solution:

^{131}I = 0.425 µCi/0.001 ml
^{126}I = 0.040 µCi/0.001 ml

Grain was fed from a metal bin that was filled at each milking. Special care was taken in handling the grain to avoid cross-contamination. The grain was weighed as it was fed and the residue subtracted to obtain total consumption.

Cows were kept as free as possible of fecal and urine accumulations on the mammary gland. Hair was clipped from the gland and back legs prior to the start of the experiment to facilitate the cleaning process.

Prior to applying the Surge® milking unit, the mammary gland was washed thoroughly with running lukewarm water and wiped dry. Each cow was milked twice daily with its individual milking unit at 0530 and 1530 hours. Fresh and preserved milk samples were taken at each morning milking and only preserved samples were taken at the afternoon milking (Appendix D). Ten cc of 37 percent formaldehyde per cubitainer* was used as the preservative. The cubitainers of fresh milk samples were iced down until analysis was performed.

Milk (3.6 liters) from one cow in each group was fed to its assigned calf in the morning and evening for the calf thyroid uptake study. Grain, hay, and water were sampled each morning from the bulk supply. Blood, for complete blood counts, and protein bound iodine (PBI), was taken from the jugular vein.

C. Analytical Procedures

1. System description

a. Gamma spectrometry was done with a system consisting of a TMC Model 404C, 400-channel pulse height analyzer and a detector consisting of two 4 x 9 inch NaI(Ti) crystals mounted facing each other with vertical spacing variable from direct contact to 14 inches separation. The crystal assembly was mounted in a specially fabricated 12-ton steel shield with 6-inch walls lined with Pb, Cd and Cu sheeting.

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*Plastic container having a capacity of 4 liters.

b. The beta system consisted of a Beckman Model 1610 wide-beta, automatic sample changer with time-of-day and manual slide options. Argon-10% methane was used as the counting gas.

2. Geometry and calibration

For this study, ^{131}I was the only calibration required since ^{126}I has similar energies. The efficiencies and geometries used in the counting systems are shown in Table 2.

D. Sample Preparation

1. Milk and Water

Efforts were made to keep the volume of milk and water constant to four liters by removing excess milk or water from the cubitainer or adding distilled water to the cubitainer, whichever was required.

2. Hay, Grain and Kimwipes

Each of the kimwipes, and the hay and grain samples was placed in a 400 ml cottage cheese container with a lid and sealed. Each container was weighed, placed in a plastic bag, sealed with masking tape, and counted.

3. Ion-exchange column

The procedure for the ion-exchange method as outlined by Porter and Carter(1) was used, with modification. In general, a plastic vial* (33 mm dia.x105 mm length) was prepared by drilling 6 holes (2 mm dia.) in the bottom. Glass wool was

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*Nalgene 250, 80 ml capacity

Table 2. Efficiency of counting systems*.

Sample type	Geometry	Efficiency**	Minimum detectable levels
Milk and water	4-liter plastic cubitainer	18.6%	10 ± 5 pCi/l
Grain and kimwipes	400 ml cottage cheese container	36.2%	80 ± 10 pCi/kg
Hay	400 ml cottage cheese container	36.2%	100 ± 15 pCi/kg
Ion-exchange column (IXC)	33 mm diameter x 150 mm length plastic column	52.0%	
Effluent	4-liter cubitainer "flat" 2" x 6" x 6"	55.0%	
AgI ppt.	2" planchet, ¼" deep	57.9%	
	Beta Counting		
AgI ppt.	2" stainless steel planchet in a 5" Bakelite holder	37.8%	

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* Samples for gamma analysis were counted for a minimum of 2,000 counts in the 0.36 MeV channel or 40 minutes and samples for beta analysis were counted for 10,000 counts or 10 minutes, whichever came first.

**The resolution of the gamma system was 9% based on the ^{137}Cs photopeak and 10 KeV per channel.

placed at the bottom of the column to avoid leakage of resin through the holes. The column was filled with Dowex 2x8 resin, Cl^- form, 20-50 mesh, 60 mm in height. Glass wool was placed on top of the resin bed. Then a 140 mm plastic funnel, fitted into the lid, was placed on top of the plastic column. One liter of milk was poured into the funnel at a flow rate of 70 to 80 ml/min. After elution, 100 ml of distilled water was used to rinse the resin. the column was then capped, placed into a small plastic bag, sealed and gamma scanned.

4. Effluent

The effluent and rinse from the ion-exchange column were collected in a beaker and transferred to a cubitainer. The cubitainer was flattened out to about 2 inches in height and 6 inches square. The flat cubitainer was placed in a plastic bag, sealed, and counted.

5. AgI precipitate

The method described by Kahn(2) was used, with modification. Essentially, a Pyrex Chromatographic column* (20 mm ID x 250 mm length) consisting of an extra-coarse fritted disc, o-rings, stopcock and clamp was used. A slurry of five grams of Dowex 2x8 resin, Cl^- form, 100-200 mesh, was poured into the column. The sides of the column were rinsed with distilled water and drained. One liter of milk was poured into a one-liter separatory funnel which was then placed on top of the column. A NaI carrier was added and mixed; then the stopcock of the funnel was adjusted so that the flow rate from the separatory funnel and through the column was 20 ml per minute. The effluent was discarded. The iodine absorbed on the resin was eluted with 2N sodium perchlorate and, finally, the iodine was precipitated as AgI after a series of steps. The precipitate was collected on a filter paper, dried, weighed for gravimetric yield, and counted in a 2-inch planchet.

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*Kontes chromaflex column No. 1K42223, Kontes Glass Co., Vineland, New Jersey.

E. Calf Thyroid Uptake

Four Holstein-Hereford calves were used. Descriptions of each animal can be found in Table 3. All the calves were kept in individual pens. Water and feed (supplemental hay and grain) were given to each on an individual basis. Each calf was fed 3.64 liters (8 lbs.) of contaminated milk from the assigned cow twice daily (0800 and 1600) for 14 to 16 days with the first milk being fed in the afternoon of August 11. To prevent cross contamination, individual stainless-steel milk buckets were used for each feeding. These calves' thyroids were analyzed *in vivo* daily for nine days and then on Monday, Wednesday and Friday for the following three weeks.

For restraining the calves, a head holder was attached to a modified milking stanchion (Plate 2). Location of the thyroid was established by manual palpation of the ventral crest of the cricoid cartilage and the first three tracheal rings. The crystal was positioned at 7 inches from the estimated center of the thyroid. Backgrounds on the calves were taken on August 10 and 11. The first count of activity in the calves began on August 12. The activity in the calves' thyroids was measured daily between the hours of 0800 and 1500. Several counts of different lengths were taken on each calf in order to obtain good counting statistics; the total counting time depended upon the length of time the animals could be restrained.

A TMC 400-channel analyzer was used for thyroid counting. Coupled to the analyzer was a 3- by 3-inch NaI crystal with a flat field collimator (Plate 1). The crystal and collimator assembly were mounted on a yoke which could be adjusted to various crystal-thyroid geometries (Plate 2).

The analyzer was calibrated with the crystal and collimator assembly in an upright attitude perpendicular to the floor surface. Disc

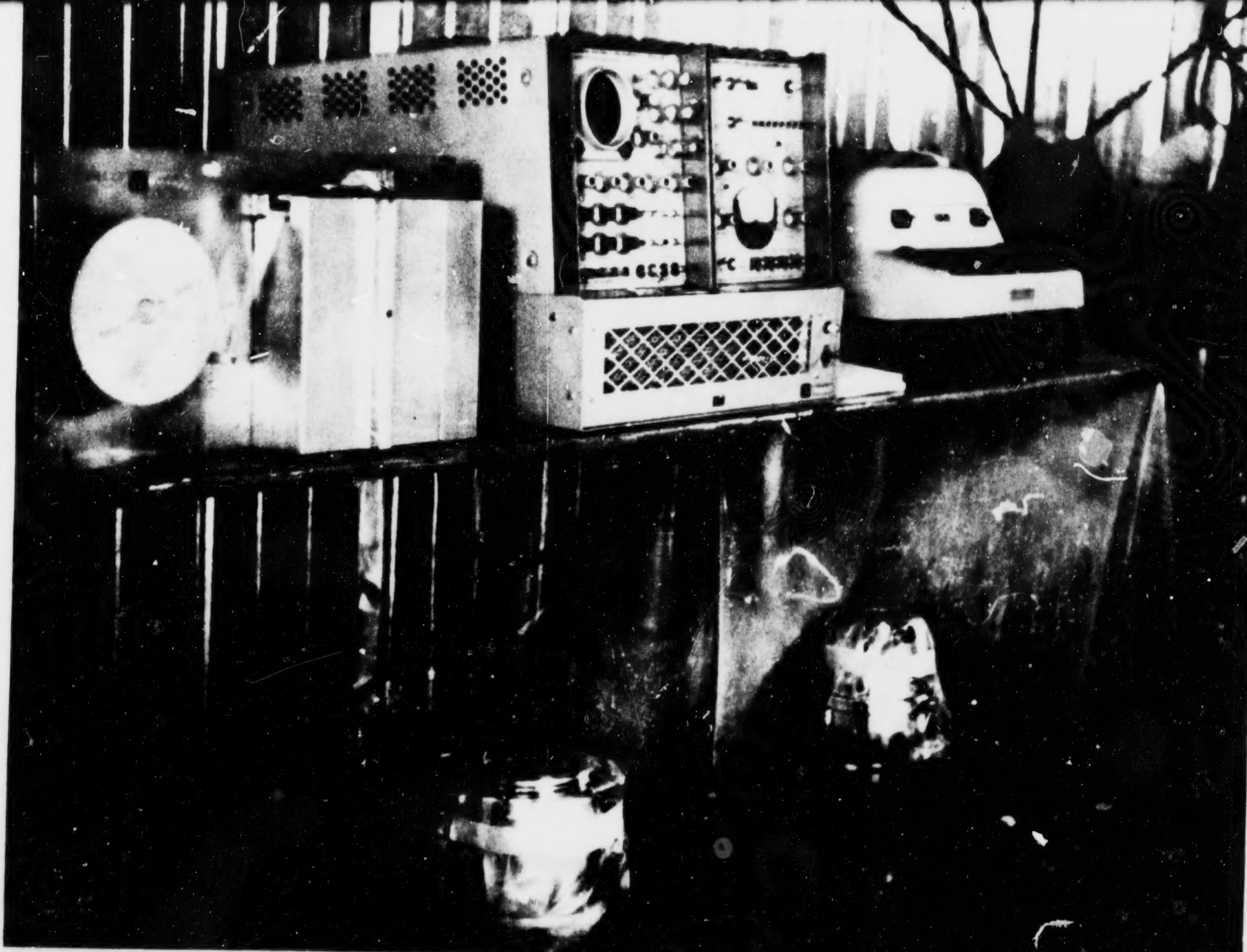

Plate 1. TMC 400 channel analyzer and 3 x 3 inch NaI crystal with and without flat field collimator.

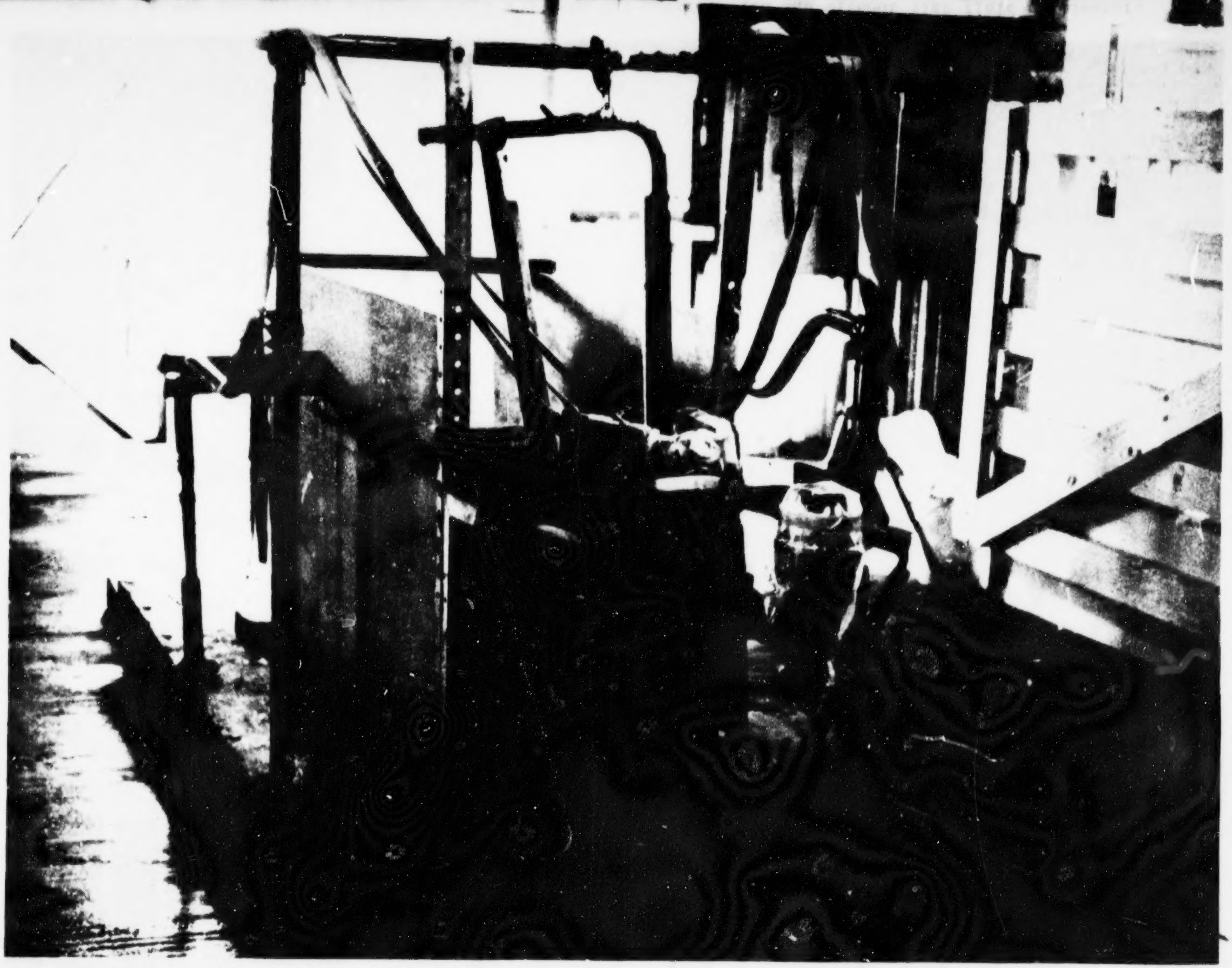

Plate 2. Crystal and collimator assembly mounted on a yoke in front of calf stanchion.

Table 3. Calf data.

Calf No.	Pen No.	Age Days	Sex	Approximate weight (kg)	Fed milk from cow No.*	Estimated thyroid** weight-g.
35	1	208	Female	204	27 Group 1	25.6
36	2	224	Female	272	21 Group 2	34.1
40	3	73	Male	125	25 Group 3	15.6
41	4	58	Female	102	28 Group 4	12.8

* Fed 3.64 liters of milk per feeding.

** Thyroid weight (grams) = 0.125 x body wt. (kg) - an empirical relationship established by BER personnel from bovine thyroid data collected from slaughter houses.

sources and a ^{131}I standard (impregnated Whatman filter) were counted on the center line at increasing distances from the face of the crystal to determine efficiency for various geometries. Disc sources used were ^{60}Co, ^{137}Cs, ^{109}Cd, ^{133}Ba, ^{22}Na, ^{65}Zn, ^{54}Mn, ^{144}Ce.

Instrument backgrounds were taken at 0800 and 1200 hours of each day of count. The crystal assembly was covered with polyethylene bags to prevent contamination and the counting area was cleaned daily to prevent high backgrounds.

RESULTS

A. Correction Factors

The use of two iodine isotopes with different half-lives but similar photopeaks requires a correction to each sample result which takes into account the variation with time of the ratio of the two isotopes. The correction factors were derived as follows:

Assuming that the biological half-life is the same for each isotope and that the only factor affecting the relative concentrations of the isotopes is physical decay, then the activity in milk at any given time after sample collection can be expressed as:

$$(1) \quad A'_{T+t} = A_o \left[F_{26} b_{26} e^{-\lambda_B T} e^{-\lambda_{26}(T+t)} + F_{31} b_{31} e^{-\lambda_B T} e^{-\lambda_{31}(T+t)}\right]$$

Where: A'_{T+t} = the observed total activity at T+t (Corrected for counter efficiency)

A_o = the total activity at time of ingestion

F_{26}, F_{31} = the fractions of ^{126}I and ^{131}I in original dose

b_{26}, b_{31} = the abundance of the gammas in 0.36 Mev photopeak

λ_B = the biological decay constant

$\lambda_{26}, \lambda_{31}$ = the physical decay constants

T = time from ingestion to milking

t = the time from milking to counting

The theoretical total activity of $^{126}I + {}^{131}I$ in the sample at time T + t is;

$$(2) \quad A_{T+t} = A_o \left[F_{26} e^{-\lambda_{26}(T+t)} + F_{31} e^{-\lambda_{31}(T+t)}\right] e^{-\lambda_B T}$$

By solving equation (1) for A_o and substituting in equation (2), the $e^{-\lambda_B T}$ will cancel, and the remaining equation can be solved for the total ^{126}I and ^{131}I activities at time T;

$$(3)\quad {}^{126}A_T = \frac{A'_{T+t}}{e^{-\lambda_{26}t}}\;\frac{F_{26}e^{-\lambda_{26}(T+t)}}{F_{26}b_{26}e^{-\lambda_{26}(T+t)} + F_{31}b_{31}e^{-\lambda_{31}(T+t)}}$$

which simplifies to;

$$(4)\quad {}^{126}A_T = \frac{A'_{T+t}F_{26}e^{-\lambda_{26}T}}{F_{26}b_{26}e^{-\lambda_{26}(T+t)} + F_{31}b_{31}e^{-\lambda_{31}(T+t)}}$$

Similarly the total ^{131}I activity at time T is;

$$(5)\quad {}^{131}A_T = \frac{A'_{T+t}F_{31}e^{-\lambda_{31}T}}{F_{26}b_{26}e^{-\lambda_{26}(T+t)} + F_{31}b_{31}e^{-\lambda_{31}(T+t)}}$$

By using equations (4) and (5), the activity of each isotope in a given sample can be calculated and the ratio of ^{126}I to ^{131}I computed.

B. Hay, Grain, and Water

Untreated hay, grain and water, fed to cows, were analyzed daily for ^{131}I activity to check for possible contamination. The average combined daily consumption of hay and grain for all cows during the experiment was 14.9 kg and 2.8 kg respectively as shown in Appendix b. Iodine-131 activity was non-detectable in hay and water. The grain samples analyzed for ^{131}I did show activities ranging from non-detectable to 260 pCi/kg. The ^{131}I detected was so low in activity that it was felt it did not affect the experiment.

C. Kimwipes

The results from the kimwipes of the cow's muzzles are shown in Appendix C. Radioactive iodine was present in all kimwipes with a range of 1.1 to 8.4 nCi; the wiping was done within 30 minutes after dosing.

D. Milk

1. Gamma spectroscopy

The milk results for all cows were recorded individually for each morning and evening milking (Appendices E - H. The data for ^{131}I and ^{126}I were calculated individually and then combined. The appendices list the nCi/liter, production of milk in liters and total µCi in milk. For all groups, the highest activity was found in the first milking after dosing. Repetitive counts were done on the milk from the first milking after dosing to determine the physical half-life of the combined radioiodines. Statistical analysis of the physical decay rates indicated that they did not significantly differ for the two cows in each group. Hence, a combined decay rate (λ) is used for each group. The group physical half-life is then calculated as ln 2 divided by λ. The data from the second through the tenth to twelfth milkings after dosing were used to calculate the effective half-life in milk for each cow. These data are shown in Table 4.

2. Ion-exchange and effluent

The ion-exchange method was used to determine its effectiveness as a rapid field method of separating iodine from milk. The results of the procedure for all cows are shown in Appendices E- H. The activities were calculated for ^{131}I and ^{126}I individually and combined to get nCi/l for both the ion-exchange column (IXC) and the effluent. Only the morning milk collections were analyzed. The effluent from the ion-exchange method was gamma scanned through August 18, 1965, This study was conducted to determine the efficiency of the IXC compared to gamma scan of a cubitainer containing milk.

Table 4. Radioiodine results in milk from gamma scan.

Group	Cow No.	Initial % 131_I	Initial % 126_I	Highest activity (µCi/liter)	Effective Half-life (hrs)	Physical Half-life (days)
I	15	79.9	20.1	0.72	13.6±0.89*	8.67 ± 0.079*
	27	79.9	20.1	0.086	18.0±0.55	
II	19	86.9	13.1	0.31	12.5±0.38	8.34 ± 0.039
	21	86.9	13.1	0.39	15.7±0.53	
III	18	93.0	7.0	0.62	12.8±0.57	8.05 ± 0.037
	25	93.0	7.0	0.18	17.8±0.85	
IV	12	100.0	0	1.70	12.6±0.70	7.81 ± 0.098
	28	100.0	0	0.49	12.4±0.46	

*value ± standard deviation

3. Silver-iodide precipitate

The AgI procedure was used to check its efficiency and sensitivity for detection of low activities of ^{131}I (below 100 pCi/liter) in milk. The beta and gamma activities of the AgI precipitates, including gravimetric yields, for all cows of the four groups are shown in Appendices E - H. The morning milk collections were the only samples analyzed. The results of the above procedure are compared to the cubitainer data obtained by gamma scan in Table 5.

E. Calf Thyroid Uptake

The results of individual calf thyroid measurements and daily amounts of radioiodine ingested are set forth in Table 6. Using equations 4 and 5 and observed total activity in the thyroid, nCi of ^{126}I and ^{131}I were calculated, corrected for physical decay back to 0800 hours of that day and summed to give thyroid burden.

The cumulative total intake is a calculated value (Table 7) which includes the total intake of milk corrected for decay to that day. The percent thyroid uptake at 24 hours as seen in Table 7 was calculated by dividing the daily thyroid burden by the cumulative total intake at one day before the thyroid count. Average values for the four calves are shown in Figure 1.

A summary of the data is presented in Table 8. The peak pCi/thyroid values vs peak pCi fed daily is a comparison of values regardless of the time the maximum activity was reached. The peak value in the cows' milk occurred at one day after dosing and the calf thyroid burden peaked 4 days later. The thyroid T_{eff} was calculated by the least squares method using the thyroid measurements from the day of maximum detectable activity to the day following the last feeding of contaminated milk, inclusive.

Table 5. Comparison of AgI to cubitainer.

Group	Cow	% Recovered (AgI/Cubitainer) beta count of AgI	gamma count of AgI
I	15	57.1 ± 12.7*	58.4 ± 12.7*
	27	47.3 ± 20.3	46.2 ± 25.2
II	19	54.0 ± 12.7	50.9 ± 16.4
	21	55.9 ± 16.0	53.7 ± 19.1
III	18	62.0 ± 17.3	59.6 ± 19.7
	25	60.3 ± 24.2	60.8 ± 24.6
IV	12	64.8 ± 16.1	75.9 ± 28.1
	28	56.6 ± 18.4	66.4 ± 32.6
Grand average		57.2 ± 6.2	59.0 ± 8.2

*value ± standard deviation

Table 6. Total nCi in milk fed daily and in thyroid.

Cow No.	27		21	
Calf No.	35		36	
Date	Daily Intake**	Thyroid Burden**	Daily Intake	Thyroid Burden
Aug. 1965				
11	310	---	1400	---
12	420	29	2100	74
13	130	64	550	220
14	58	81	170	280
15	25	82	62	320
16	10	97	24	330
17	5.6	84	12	260
18	4.7	68	8.4	290
19	2.6	66	4.3	240
20	2.7	60	2.7	230
21	1.8	---	2.8	---
22	2.0	---	1.7	---
23	1.5	48	1.9	160
24	1.3*	---	2.01	---
25		32	1.5	150
26		---	1.5*	---
27		27		130
30		21		71
Sept. 1		12		76
3		10		57
8		6.5		32
15		1.8		16
22		---		56

---

*Last feeding of contaminated milk.
**nCi of activity
---indicates thyroid burden not measured.

Table 6(cont')

Cow No.	25		28	
Calf No.	40		41	
Date	Daily Intake	Thyroid Burden	Daily Intake	Thyroid Burden
Aug. 1965				
11	660	---	1800	---
12	660	86	1800	170
13	270	160	390	320
14	110	200	100	450
15	34	210	28	450
16	12	210	7.9	440
17	11	190	6.0	400
18	7.1	160	5.3	400
19	4.3	140	3.4	360
20	2.8	130	2.2	310
21	2.7	---	2.0	---
22	2.1	---	1.4	---
23	1.5	92	1.8	240
24	2.3	---		---
25	2.0	64		190
26	1.8*	---		---
27		54		140
30		30		120
Sept. 1		24		100
3		21		78
8		9.8		48
15		3.5		19
22		---		8.5

Table 7. Percent uptake in calf thyroid.

Cow No.		27			21	
Calf No.		35			36	
Date	Cumulative Intake(nCi)*	Thyroid Burden(nCi)**	% Uptake	Cumulative Intake(μCi)	Thyroid Burden(μCi)	% Uptake
Aug. 1965						
11	310	29	9.4	1.4	.074	5.3
12	700	64	9.1	3.4	.22	6.5
13	770	81	10.5	3.7	.28	7.6
14	770	82	10.6	3.5	.32	9.1
15	740	97	13.1	3.3	.33	10.0
16	690	84	12.2	3.1	.26	8.4
17	680	68	10.0	2.9	.29	10.0
18	630	66	10.5	2.7	.24	8.9
19	610	60	9.8	2.5	.23	9.2
20	550	---		2.3	---	
21	510	---		2.1	---	
22	510	48	9.4	1.9	.16	8.4
23	470	---		1.8	---	
24	440***	32	7.3	1.7	.15	8.8
25				1.5	---	
26				1.4	.13	9.3

* corrected for decay to date.
** twenty-four hours after date.
*** last feeding of contaminated milk.
--- indicates thyroid burden not measured.

Table 7. (Cont')

Cow No.	25			28		
Calf No.	40			41		
Date	Cumulative Intake(μCi)	Thyroid Burden(μCi)	% Uptake	Cumulative Intake(μCi)	Thyroid Burden(μCi)	% Uptake
Aug. 1965						
11	0.66	.086	13.0	1.8	.17	9.4
12	1.3	.16	12.3	3.4	.32	9.4
13	1.4	.20	14.3	3.5	.45	12.8
14	1.4	.21	15.0	3.3	.45	13.6
15	1.3	.21	16.2	3.1	.44	14.2
16	1.2	.19	15.8	2.8	.40	14.3
17	1.2	.16	13.3	2.6	.40	15.4
18	1.1	.14	12.7	2.4	.36	15.0
19	0.99	.13	13.1	2.2	.31	14.1
20	0.92	---		2.0	---	
21	0.88	---		1.8	---	
22	0.85	.092	10.8	1.7	.24	14.1
23	0.78	---		1.6		
24	0.72	.064	8.9			
25	0.67	---				
26	0.62	.054	8.7			

Figure 1. Average values for the four calves.

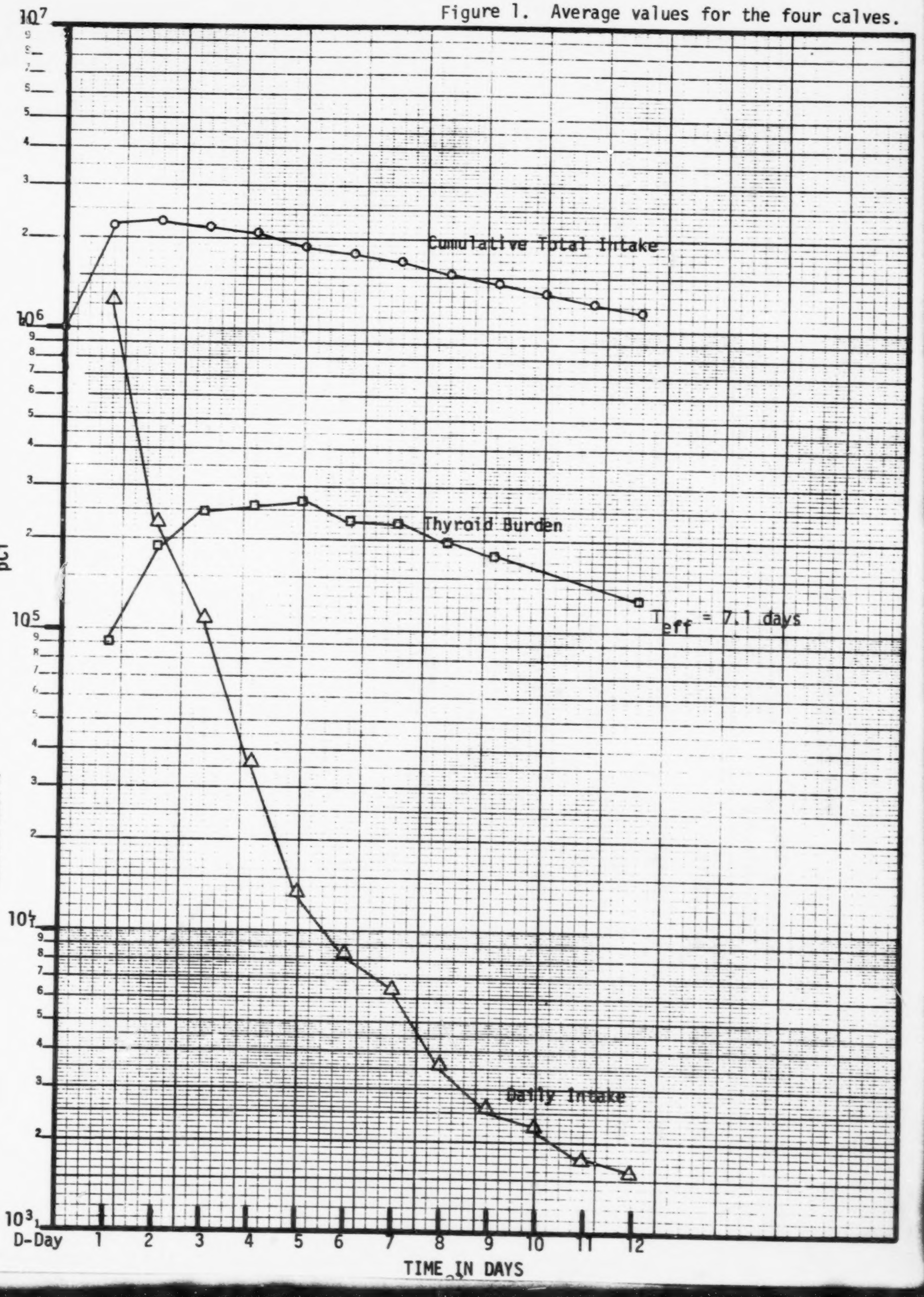

Table 8. Summary of calf thyroid data.

Calf No.	Cow No.	Initial % ^{126}I of Total activity	$\frac{\text{Peak thyroid burden}}{\text{peak daily intake}}$	Thyroid T_{eff}(days)	Thyroid average percent uptake
35	27	20.1%	0.23	6.25 ± 0.53*	10.2 ± 1.5*
36	21	13.1%	0.16	8.31 ± 0.69	8.4 ± 1.4
40	25	7.0%	0.32	5.74 ± 0.22	12.8 ± 2.4
41	28	0.0%	0.25	9.55 ± 1.07	13.2 ± 2.1

* value ± standard deviation

DISCUSSION

In all experimental groups, T_{eff} for total activity in milk after the single oral ingestion was between 10 and 20 hours. It is apparent that there is no significant difference in the kinetics of secretion of ^{131}I and ^{126}I in milk for the four combinations of ^{131}I and ^{126}I used in this study. It should be noted that the secretion of iodine after ingestion was very rapid. Activity was found on the kimwipes from the cows' muzzles 30 minutes after ingestion. This is indicative of the rapid uptake of radioiodine and secretion into the cows' saliva. The peak total activity in milk in each case was found in the first milking which was five hours after dosing. The physical decay of ^{131}I and ^{126}I mixtures in cubitainer milk, from the initial collection after ingestion, gave different half-lives. The radioactive decay in milk from cows in Group IV, which received 100% ^{131}I, occurred with a 7.81 day half-life. For the Group III milk, from cows receiving 93.0% ^{131}I + 7.0% ^{126}I, it was 8.05 days. The Group II milk, from cows receiving 86.9% ^{131}I + 13.1% ^{126}I, had an 8.34 day half-life and for the Group I milk, from cows receiving 79.9% ^{131}I + 20.1% ^{126}I, it was 8.67 days. This suggested that the ^{131}I and ^{126}I isotopes were secreted in milk from cows in the same combinations as they were given orally. Statistical analysis of the decay rates for each group indicates a significant difference in rates between the groups (Pr. < .01). This implies that we can use the decay rate to estimate the relative proportions of the two isotopes in the sample.

The linear relationship that exists between the observed decay rate (λ) and percent ^{126}I or ^{131}I can be developed theoretically as follows:

$$(6) \quad A'_t = A_o[F_{26}e^{-\lambda_{26}t} \quad F_{31}e^{-\lambda_{31}t}]$$

Eq. (6) describes the amount of combined ^{126}I and ^{131}I which would be observed at any time, t.

When plotted on semilog graph paper, a one-to-one conversion of A'_t to ln A'_t is accomplished. The slope of the curve at any time, t, is the negative of the decay coefficient, λ, of a single component decay line plotted tangential to the curve of Eq. (6) at time, t. The slope is also equivalent to the first derivative of the natural logarithm of Eq. (6), giving:

$$(7)\quad -\lambda = \frac{d}{dt} \ln \left[A_o(F_{26}e^{-\lambda_{26}t} + F_{31}e^{-\lambda_{31}t})\right], \text{ or}$$

$$(8)\quad -\lambda = -\frac{F_{26}\lambda_{26}e^{-\lambda_{26}t} + F_{31}\lambda_{31}e^{-\lambda_{31}t}}{F_{26}e^{-\lambda_{26}t} + F_{31}e^{-\lambda_{31}t}}$$

Since the values F_{26} and F_{31} can be expressed as complementary proportions, the sum can be set equal to unity. Thus

$$(9)\quad F_{26} + F_{31} = 1.0$$

Since the time of comparison is from the start of repetitive counting, t can be set equal to zero in Eq. (8), giving:

$$(10)\quad \lambda = \frac{F_{26}\lambda_{26} + F_{31}\ \lambda_{31}}{F_{26} + F_{31}}$$

Substitution of Eq. (9) into Eq. (10) gives:

$$(11)\quad \lambda = \lambda_{26}(1-F_{31}) + \lambda_{31}F31, \text{ or}$$

$$(12)\quad \lambda = \lambda_{26} + (\lambda_{31} - \lambda_{26})\ F_{31}$$

The theoretical curve, obtained by substituting $\lambda_{26} = 0.0525$ and $\lambda_{31} = 0.0858$ in Eq. (12) is:

$$(13)\quad \lambda = 0.0525 + 0.0333\ F_{31}$$

The curves calculated from the experimental data are:

$$(14)\quad \lambda_{\text{Gamma}} = 0.045 + 0.044\ F_{31}, \text{ and}$$

$$(15)\quad \lambda_{\text{Beta}} = 0.037 + 0.045\ F_{31}$$

The accompanying graph, Figure 2, is a plot of the results. The beta and gamma lines are essentially parallel to each other but not to the theoretical line. The fact that the observed and theoretical lines approach one another over increasing percentages suggests the presence of contaminating beta-gamma emitter.

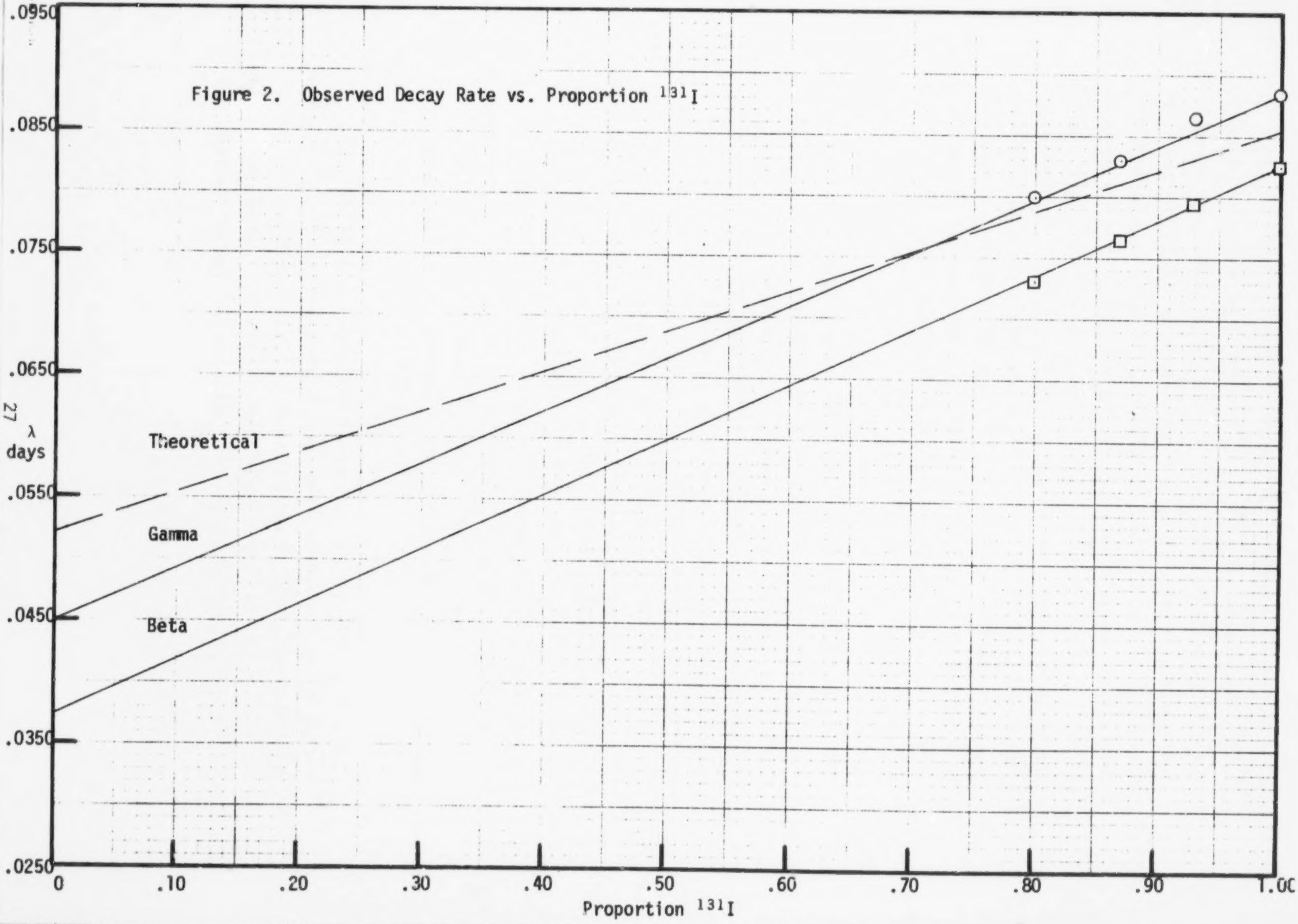

Figure 2. Observed Decay Rate vs. Proportion ^{131}I

The average recovery of ^{131}I and ^{126}I by the AgI (Beta) procedure never exceeded 64.8% compared to the cubitainer data. One explanation for radioactive iodine loss is that it could be due to the use of an analytical procedure requiring many steps. The AgI precipitation method as used herein would be unsuitable for field use due to the low ^{131}I recoveries. It should also be noted that the recoveries by the AgI method were lower when the activity levels in the cubitainer were below 1,000 pCi/liter in milk. This effect was also noted in the ion-exchange procedure. The ^{131}I and ^{126}I recovery as measured by the gamma scans of the AgI was 59.0 ± 8.2%* compared to the cubitainer milk. This was not significantly different from the recovery obtained by beta counting.

The efficiency of the resin in the ion-exchange column, expressed as percent retention, was also calculated. The results are shown in Table 9 and graphically in Figure 3. It can be seen that the efficiency of the resin decreases as the total activity in the milk decreases. The correlation coefficient between the efficiency of the resin and the logarithm of total activity in milk is 0.553.

It should be noted that the retention of iodine by the resin decreases as the time between ingestion and milking increases as shown in Figure 4. The decreased retention by the IXC could be attributed to decreasing activity with time and in turn decreasing retention with lower activity. The fact that the efficiency of resin appears to drop with decreased activity in milk (Figure 3) is of considerable interest. Further experiments are planned to investigate these findings.

The similarities of the milk secretion curves, despite the varying ratios of the two radioiodines, permit grouping the data for an overall consideration of iodine metabolism as it applies to milk. If the activity in milk is normalized by setting the first value at 100%, and subsequent values accordingly, and taking an average of the resultant

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*value ± standard deviation.

Table 9. Percent retained by the ion-exchange column.

Cow	Day	^{131}I + ^{126}I nCi/liter			% Retained*
		IXC	Effluent		IXC
15	D+1	460	13		97.2
	D+2	180	3.6		98.0
	D+3	52	1.5		97.2
	D+4	14	0.4		96.9
	D+5	4.7	0.21		95.7
	D+6	2.8	0.14		95.2
	D+7	0.99	0.12		89.2
				Avg.	95.6
27	D+1	71	12		85.5
	D+2	25	3.3		88.3
	D+4	4.3	0.55		88.6
	D+5	1.9	0.28		87.2
	D+6	0.90	0.18		83.3
				Avg.	86.6
19	D+1	280	8.9		96.9
	D+2	94	3.3		96.6
	D+4	5.9	0.31		95.0
	D+5	1.8	0.13		93.3
	D+6	0.75	0.11		87.2
	D+7	0.56	0.17		76.7
				Avg.	90.9
21	D+1	370	12		96.8
	D+2	140	6.0		95.9
	D+4	13	0.47		96.5
	D+5	4.4	0.25		94.6
	D+6	2.2	0.26		93.2
	D+7	0.95	0.29		76.6
				Avg.	92.3
18	D+5	3.4	0.19		94.7
	D+6	1.6	0.14		92.0
	D+7	1.0	0.083		92.3
				Avg.	93.0
25	D+1	130	12		91.5
	D+2	55	4.7		92.1
	D+4	7.7	0.27		96.6
	D+5	3.4	0.18		95.0
	D+6	0.79	0.090		89.8
	D+7	0.77	0.28		73.3
				Avg.	89.7

Table 9. (Cont')

$^{131}I + {}^{126}I$ nCi/liter

Cow	Day	IXC	Effluent		% Retained* IXC
12	D+1	1100	59		94.9
	D+2	260	5.6		97.9
	D+4	10	0.41		96.1
	D+5	4.0	0.24		94.3
				Avg.	95.8
28	D+1	380	11		97.2
	D+2	93	3.0		96.9
	D+3	23	0.97		96.0
	D+4	7.8	0.25		96.9
	D+5	1.9	0.14		93.1
				Avg.	96.0
				Grand Avg.	92.49±3.34**

$^{*}\left(\frac{IXC}{IXC = Effluent}\right)(100)$

**value ± standard deviation

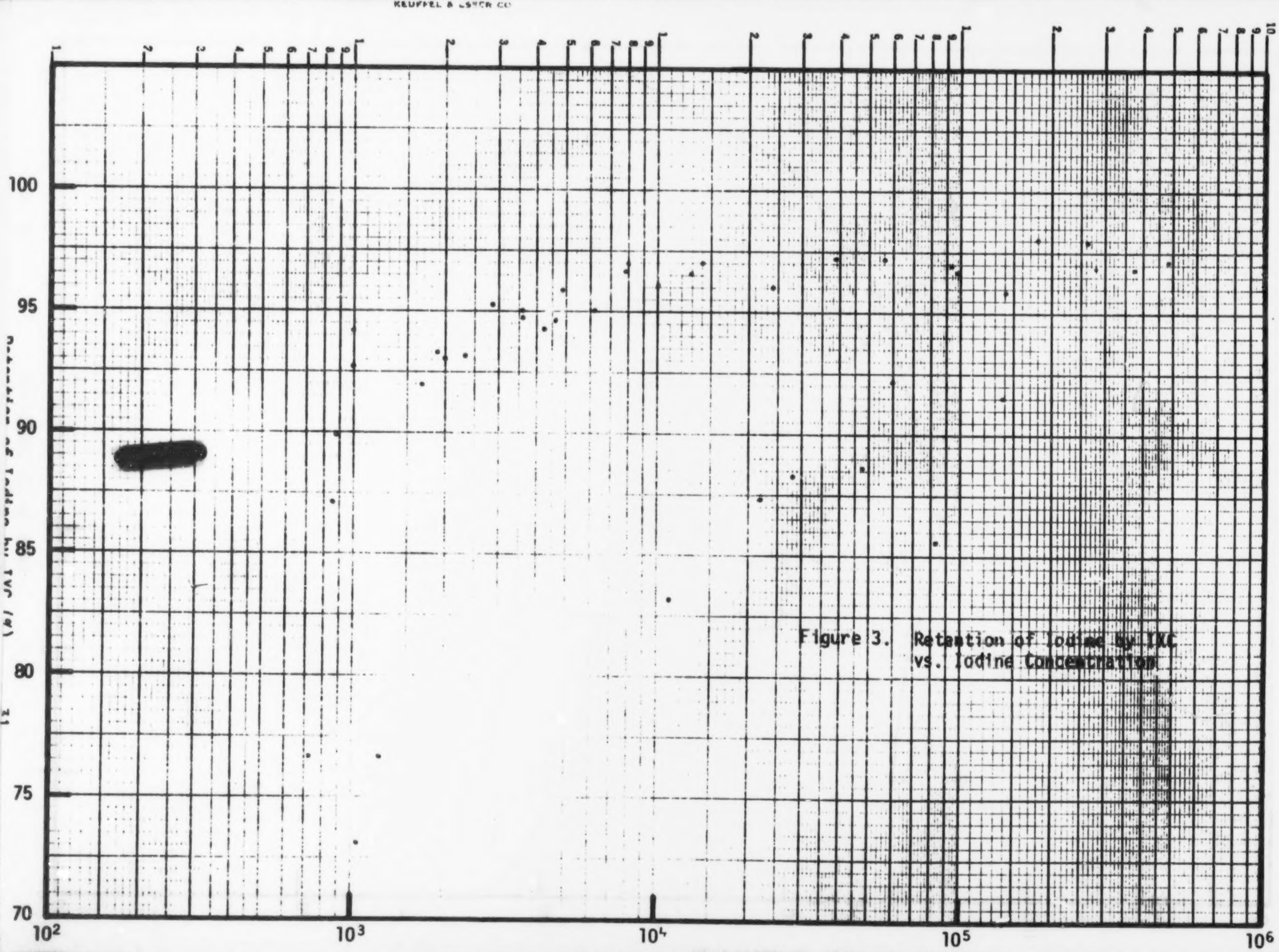

Figure 3. Retention of Iodine by IXC vs. Iodine Concentration

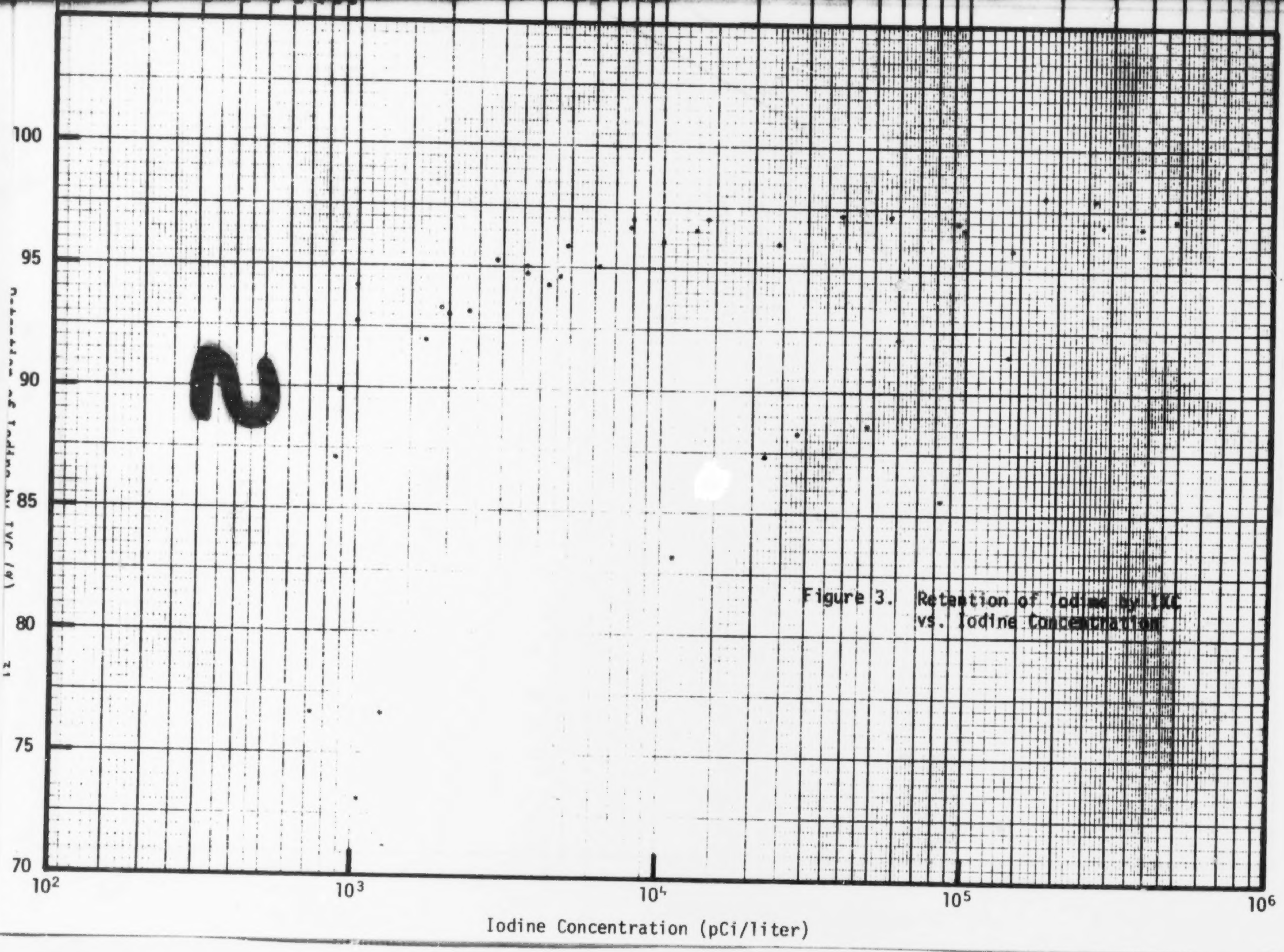

Figure 3. Retention of Iodine by IXC vs. Iodine Concentration

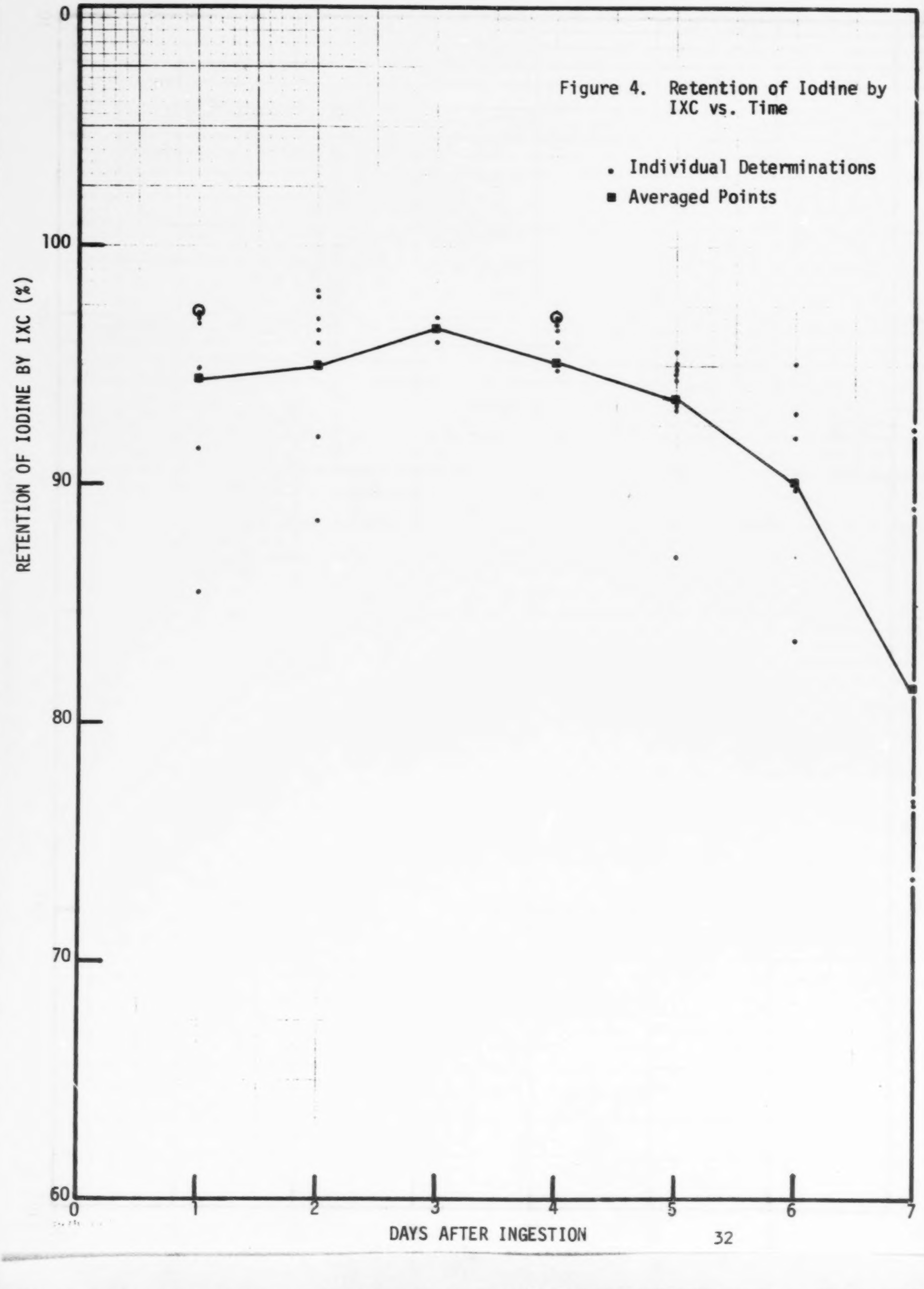

Figure 4. Retention of Iodine by IXC vs. Time

8 values for each milking, then the curve in Figure 5 can be constructed. The first two points on the curve indicate a 30.4 hour T_{eff} during the first day after ingestion which suggests that absorption of the oral dose is not complete in five hours even though the measured peak value for radioiodines in milk occurred in the first milking. The true peak may have occurred sometime between the first and second milking. This curve suggests a 15.3 ± 0.43* hour T_{eff} for radioiodine in milk from the first day through the fifth day after ingestion. This gradually increases to about 3.2 days thereafter. If the oral dose had been completely absorbed in five hours, the 15.3 hour effective half-life would have been observed from the first milking through the fifth day.

The cumulative percent of the ingested dose secreted in milk in 7 days, when rounded to the nearest 0.1%, was identical to that for 12 days because of the low secretion after 7 days. The data agree with that of Lengemann, et al (3,4) and are shown in Table 10 along with other pertinent data.

Several interesting correlations are evident in the data of Table 10. A plot of log cumulative percent in milk vs PBI (Figure 6) yields the best fitting straight line with a correlation coefficient of -0.885, if the data from cow 12 are omitted. The PBI value for this cow dropped from 3.95µg% before the experiment to 2.8µg% after the experiment indicating some change in iodine metabolism was occurring during this period. Thus, the cows with a high PBI secreted less radioiodine in milk.

The log of peak µCi/liter when plotted against average liters per day (Figure 7) indicates that the higher producing cows secreted fewer µCi/liter. The correlation coefficient for these data is -0.767.

A similar calculation between total µCi in the first milking and average liters/day yields a correlation coefficient of -0.488. The higher producing cows also secreted less cumulative percent into the milk in 12 days than the lower producing cows. (correlation coefficient = -0.562)

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*Value ± standard deviation.

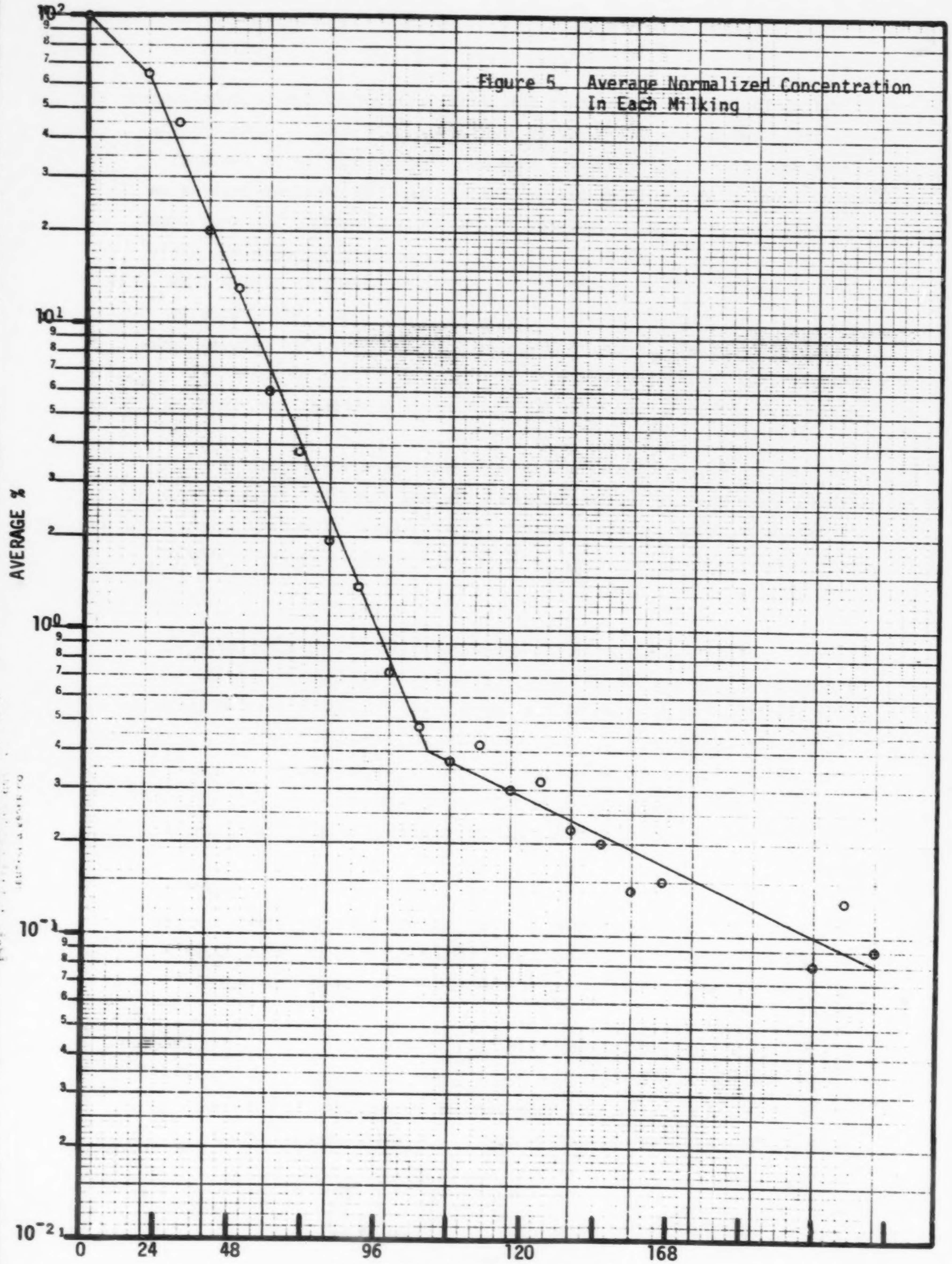


Figure 5 Average Normalized Concentration In Each Milking

Table 10. Summary of data for correlation analyses.

Cow	Average liters/day	Peak µCi/liter	1st milking total µCi	Cumulative % in milk - 12 days	Blood PBI	% Retained by IXC
12	15.6	1.7	12.0	22.2	3.95	95.8
18	16.2	.620	3.7	10.0	3.12	93.0
19	16.9	.31	2.0	6.6	3.10	90.9
15	19.7	.72	5.2	12.2	2.53	95.6
21	21.7	.39	2.8	9.16	2.80	92.3
28	27.0	.49	5.1	11.8	3.00	96.0
27	31.9	.086	1.1	3.4	3.80	86.6
25	35.6	.18	2.4	6.7	3.20	89.7

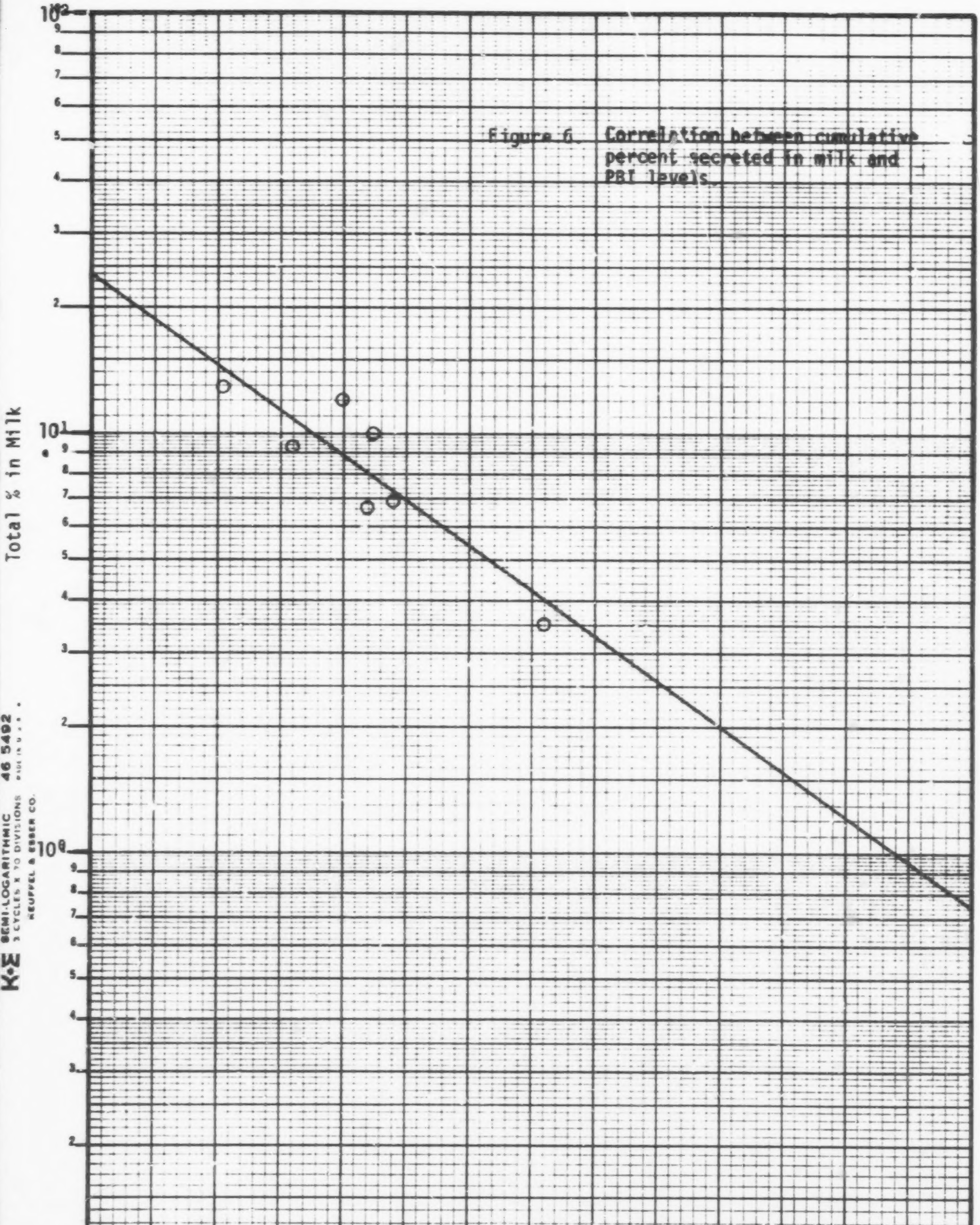
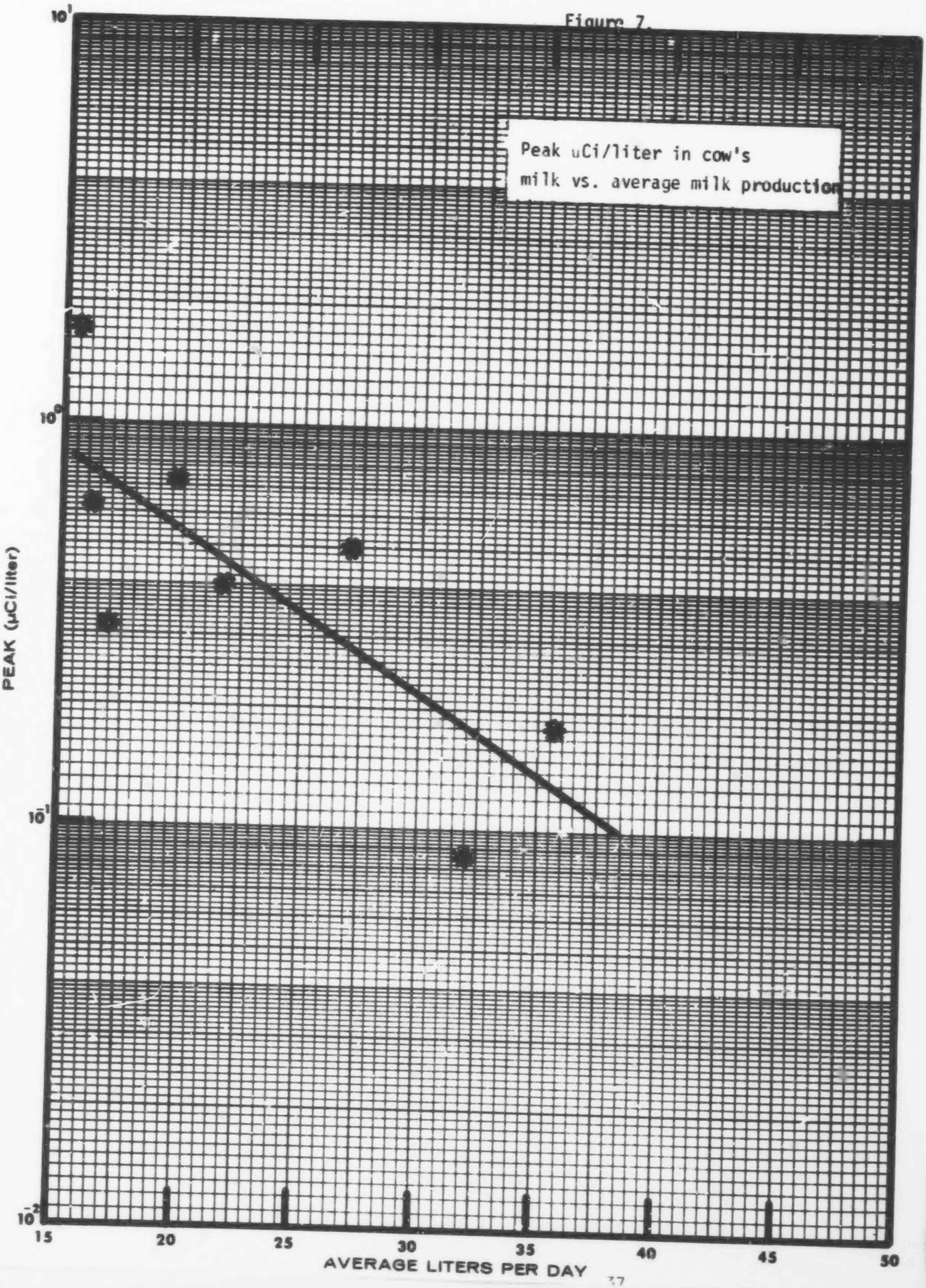


Figure 6. Correlation between cumulative percent secreted in milk and PBI levels.

Figure 7.


Peak uCi/liter in cow's
milk vs. average milk production
10^1
10^0
10^{-1}
10^{-2}
PEAK (µCi/liter)
15
20
25
30
35
40
45
50
AVERAGE LITERS PER DAY

The equations of the regression lines are:

for Figure 6; $\% = 179e^{-1.01P}$

where $\%$ = total % of ingested dose, secreted in milk for 12 days

P = PBI in μg%

for Figure 7; $C = 3.3e^{-0.0914L}$

where C = Peak μCi/liter

L = Avg. liters/day

If the milk secretion data are to be used to study radioiodine metabolism, then the data of each milking should be decay corrected to time of ingestion. When this was done, for example, to determine the true percent of ingested iodine secreted in milk, the percent in the milk increased only slightly (from 10.0 to 10.7% in one case and from 3.4 to 3.8% in another). Probably, the rapid change in concentration with time causes only a slight error if decay is ignored.

The percent thyroid uptake in the calves (Table 7) was calculated by using the decay-corrected, cumulative radioiodine intake on a given day and the measured thyroid content of the following day. These types of data are useful since a measurement of radioiodine in milk can be used to estimate thyroid content one day after ingestion of the milk. The standard method for measuring percent uptake corrects the thyroid content for the radioactive decay for one day. Thus, to compare these data with standard percent uptakes, each of the percent uptakes in Table 7 should be divided by 0.918.

The thyroid average % uptake for each calf (Table 7) decreases as the age of the calf (Table 3) increases (correlation coefficient = -0.968).

SUMMARY AND CONCLUSIONS

Table 11 summarizes some pertinent data from the milk experiments. The numbered paragraphs below indicate conclusions with respect to the numbered objectives of Section 1.

1. Theoretical equations and experimental results support a conclusion that it is possible, over the range of relative percentages of ^{126}I employed in this study (0-20.1), to detect and quantitate ^{126}I in the presence of ^{131}I in milk samples by the simple analytical technique of determination of the decay rate of the combined radioiodines by taking repetitive gamma scans on the same milk sample - even though the individual gamma energies cannot be resolved.

2. The levels of ^{126}I - ^{131}I in milk from all cows given a single ingestion dose of these radioiodines mixed in various proportions peaked at five hours (first milking) after oral ingestion. Following the second milking, secretion exhibited a T_{eff} ranging from 12.5 to 18.0 hours with an average value of 14.4 hours. The detection of radioiodine activity on cow saliva samples within 30 minutes after oral ingestion of the dose attests to the rapid uptake and secretion of radioiodine by the cow. The percent of ingested dose which appeared in the milk of individual cows correlated inversely with the PBI level of the cow. High producing cows apparently had a lower concentration of radioiodine in their milk than the low producers.

3. Calf thyroid percent uptake from ingestion of milk contaminated with radioiodine ranged from 8.4 to 13.2% with an average of 11.15%. The percent uptake correlated inversely with the age of the calves. The T_{eff} in the thyroid ranged from 5.74 to 9.55 days with an average of 7.46 days.

Table 11. Summary of the milk results.

Group	Cow	Oral Dose µCi	Percent ^{131}I	Percent ^{126}I	Peak value in milk (nCi/l)	T_{eff} for milk hours	T 1/2 in milk (days)	Average % Recovered by IXC	Average % Recovered by AgI, beta count	Average % Recovered by AgI, gamma count
I	15	119.6	79.9	20.1	720	13.6	8.67	114.4±17.7*	57.1±12.7*	58.4±12.7*
	27				86	18.0		78.3±17.6	47.3±20.3	46.2±25.2
II	19	122.2	86.9	13.1	310	12.5	8.34	107.6±16.9	54.0±12.7	50.9±16.4
	21				390	15.7		107.8±16.7	55.9±16.0	53.7±19.1
III	18	114.2	93.0	7.0	620	12.8		111.4±20.6	62.0±17.3	59.6±19.7
	25				180	17.8	8.05	108.3±20.0	60.3±24.2	60.8±24.6
IV	12	116.8	100.0	0	1700	12.6		126.7±16.3	64.8±16.1	75.9±28.1
	28				490	12.4	7.81	118.2±21.5	56.6±18.4	66.4±32.5
					Average	14.4		109.1±18.4	57.2± 6.2	59.0± 8.2

*value ± standard deviation

4. The recovery of ^{131}I and ^{126}I from milk by use of an ion-exchange column, when compared to a gamma scan of milk in the cubitainer, had a large standard deviation indicating further experimentation is desirable prior to field use. Apparently the recovery efficiency of the ion-exchange resin decreases with lower activities of metabolized radioiodine in milk. In addition, low recovery and large standard deviation in determining the radioiodine in milk by our AgI precipitation method suggests this method is not suitable for quantitative assay.

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7. Ibid, page 98

APPENDICES

Appendix A. Data on Cows Prior to Experiment
Appendix B. Cow Milk and Feed Data
Appendix C. Activity on Kimwipes of Cows' Muzzles
Appendix D. Number of Samples Collected Daily
Appendix E. Milk Data for Group I Cows
Appendix F. Milk Data for Group II Cows
Appendix G. Milk Data for Group III Cows
Appendix H. Milk Data for Group IV Cows
Appendix I. Half-lives (Days) as Determined from Beta Decay of AgI Precipitates

APPENDIX A

DATA ON COWS PRIOR TO EXPERIMENT

Group	Cow No.	Approximate Age	Lactation Period	Days in Production As of 8/11/65	Days Pregnant As of 8/11/65	Total Production Liters	Weight of Cows(kg)	DHIA Value* 8/1/65	DHIA Value* 9/1/65
I	15	8.5 Yrs.	6th	215	42	4871.8	707.6	100	100
	27	4.0 Yrs.	2nd	7	NP**	155.5	689.5	N R***	105
II	21	3.5 Yrs.	2nd	73	NP	1779.6	585.1	N R	99
	19	9.0 Yrs.	7th	213	NP	4774.1	626.0	111	110
III	18	7.0 Yrs.	5th	177	110	4019.6	653.2	93	95
	25	7.0 Yrs.	5th	24	NP	667.3	630.5	89	90
IV	28	7.0 Yrs.	5th	110	69	3520.5	705.3	114	129
	12	5.0 Yrs.	3rd	173	85	3699.1	712.1	94	96

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*DHIA - The Dairy Herd Improvement Association - By applying certain factors to the extrapolated records, a herd average cow standard of 100 is established. Each cow is rated monthly in comparison to this herd average cow. The standard takes into account the 305 day milk production, butterfat content and age of the cow.

**NP - Not Pregnant

***N R - No rating

APPENDIX 3

COW MILK AND FEED DATA

Group	Cow No.	Average Daily Production-Liters		% Butterfat		Average Daily Fat Content-Grams		Average Daily Consumption(kg)	
		7/20/65	8/11/65	3/1/65	9/1/65	7/20/65-8/11/65	8/11/65-9/1/65	Hay	Grain
I	15	20.2	19.7	3.0	2.8	606.0	551.6	14.9	2.8
	27	25.9	31.9	N T*	2.5	N T	797.5	14.9	2.8
II	21	23.8	21.7	3.2	3.5	761.6	759.5	14.9	2.8
	19	18.4	16.9	4.0	3.7	736.0	625.2	14.9	2.8
III	18	17.7	16.2	2.9	3.1	513.3	502.2	14.9	2.8
	25	31.8	35.6	2.6	2.4	826.8	854.4	14.9	2.8
IV	28	28.4	27.0	3.0	2.8	852.0	756.0	14.9	2.8
	12	16.3	15.6	3.5	3.4	570.5	530.4	14.9	2.8

*N T - No test

APPENDIX C

ACTIVITY OF KIMWIPES OF COWS' MUZZLES

Group	Cow	Time Activity Given	Time of Wipes	^{131}I (nCi)	^{126}I (nCi)	Total (nCi)
I	15	0955	1017	3.0	2.1	5.1
	27	1025	1031	0.74	0.52	1.3
II	19	1010	1019	1.8	0.73	2.5
	21	1000	1018	2.7	1.1	3.8
III	18	1020	1030	0.86	0.27	1.1
	25	0950	1016	6.4	2.0	8.4
IV	12	1005	1019	1.5	0	1.5
	28	0945	1015	6.3	0	6.3

APPENDIX D

NUMBER OF SAMPLES COLLECTED DAILY

		Individual Samples Milk			
		a.m.		p.m.	
Date	Group	F	NF	F	NF
8/10/65	I	2	2	2	0
to	II	2	2	2	0
9/1/65	III	2	2	2	0
	IV	2	2	2	0

F - Formalin

NF - No Formalin

Hay, water and grain samples were taken daily from the common source.

APPENDIX E

Milk Data for Group I Cows (15 and 27) Received 79.9% ^{131}I + 20.1% ^{126}I.

Table E-1 Cow 15 Radioiodine Results in Milk from Gamma Scan

Table E-2 Cow 27 Radioiodine Results in Milk from Gamma Scan

Table E-3 Repetitive Counts on D-Day Milk

Table E-4 Radioiodine Results from Ion-exchange Study

Table E-5 Radioiodine Results from Silver-iodide Procedure

Table E-6 Comparison of Radioiodine Results Between Silver-iodide Procedure and Gamma Scan of Cubitainer

Figure E-1 Repetitive counts on the First Milk Sample from Group I Cows

APPENDIX E

Table E-1 Cow 15 Radioiodine Results in Milk from Gamma Scan

Date		nCi/liter			Production Liters	Total ^{131}I + ^{126}I µCi
		^{131}I	^{126}I	Sum		
August 1965						
11	p.m.	580	150	730	7.2	5.2
12	a.m.	310	80	390	11.3	4.4
	p.m.	240	62	300	7.2	2.2
13	a.m.	120	32	150	10.9	1.6
	p.m.	59	16	75	8.2	0.62
14	a.m.	30	8.3	38	12.2	0.46
	p.m.	9.7	2.7	12	7.2	0.086
15	a.m.	8.1	2.2	10	13.1	0.13
	p.m.	5.1	1.5	6.6	8.2	0.054
16	a.m.	2.9	0.86	3.8	12.7	0.048
	p.m.	1.6	0.48	2.1	7.2	0.015
17	a.m.	1.2	0.36	1.6	12.7	0.020
	p.m.	1.1	0.34	1.4	7.2	0.010
18	a.m.	0.99	0.32	1.3	11.8	0.015
	p.m.	0.80	0.26	1.1	8.2	0.0090
19	a.m.	0.69	0.23	0.91	11.8	0.011
	p.m.	0.19	0.06	0.25	8.2	0.0020
20	a.m.	0.36	0.12	0.48	11.3	0.0054
	p.m.	0.57	0.20	0.77	8.2	0.0063
21	a.m.	0.29	0.10	0.39	11.3	0.0044
	p.m.	0.50	0.18	0.68	8.6	0.0058

APPENDIX E

Table E-I (continued)

Date		ηCi/liter			Production	Total ^{131}I +
		^{131}I	^{126}I	Sum	Liters	^{126}I µCi
22	a.m.	0.70	0.26	0.96	12.2	0.012
	p.m.	0.26	0.096	0.36	7.2	0.0026
23	a.m.	0.21	0.080	0.30	11.3	0.0034
	p.m.	0.72	0.27	0.99	7.7	0.0076
24	a.m.	0.18	0.068	0.24	11.7	0.0028
25	a.m.	0.18	0.071	0.25	12.2	0.0031
26	a.m.	0.16	0.066	0.23	12.2	0.0028
	p.m.	0.15	0.065	0.22	7.2	0.0016
27	a.m.	0.16	0.068	0.23	12.2	0.0028
30	a.m.	0.13	0.059	0.18	11.3	0.0020
31	p.m.	0.10	0.051	0.16	8.6	0.0014
September						
1	a.m.	0.095	0.048	0.14	11.3	0.0016
2	p.m.	0.11	0.058	0.17	8.6	0.0015

APPENDIX E

Table E-2 Cow 27 Radioiodine Results in Milk from Gamma Scan

Date		ηCi/liter			Production	Total ^{131}I + ^{126}I μCi
		^{131}I	^{126}I	Sum		
August 1965						
11	p.m.	69	17	86	13.1	1.1
12	a.m.	55	14	70	17.7	1.2
	p.m.	36	9.6	46	12.7	0.58
13	a.m.	17	4.5	21	17.7	0.37
	p.m.	11	3.0	14	22.2	0.31
14	a.m.	7.4	2.1	9.4	19.5	0.18
	p.m.	5.0	1.4	6.5	14.0	0.091
15	a.m.	3.2	0.91	4.1	19.5	0.080
	p.m.	2.2	0.65	2.9	12.7	0.037
16	a.m.	1.3	0.37	1.6	20.3	0.032
	p.m.	0.89	0.27	1.2	13.6	0.016
17	a.m.	0.61	0.19	0.79	12.3	0.0098
	p.m.	0.68	0.21	0.89	13.1	0.012
18	a.m.	0.50	0.16	0.66	25.4	0.017
	p.m.	0.51	0.16	0.67	13.1	0.0088
19	a.m.	0.47	0.15	0.62	19.5	0.012
	p.m.	0.30	0.099	0.40	13.1	0.0052
20	a.m.	0.23	0.077	0.30	19.0	0.0057
	p.m.	0.20	0.069	0.27	14.1	0.0038
21	a.m.	0.35	0.12	0.48	19.9	0.0096
	p.m.	0.21	0.075	0.29	21.3	0.0062

APPENDIX E

Table E-2 (continued)

Date		ηCi/liter			Production Liters	Total ^{131}I + ^{126}I μCi
		^{131}I	^{126}I	Sum		
22	a.m.	0.15	0.055	0.21	19.0	0.0040
	p.m.	0.25	0.091	0.34	12.6	0.0043
23	a.m.	0.14	0.054	0.20	18.5	0.0037
	p.m.	0.16	0.060	0.22	12.6	0.0028
24	a.m.	0.14	0.055	0.20	17.2	0.0034
	p.m.	0.15	0.058	0.21	12.6	0.0026
25	a.m.	0.14	0.057	0.20	16.4	0.0033
	p.m.	0.14	0.058	0.20	13.5	0.0027
26	a.m.	0.11	0.047	0.16	19.0	0.0030
	p.m.	0.15	0.061	0.21	12.6	0.0026
27	a.m.	0.14	0.058	0.19	18.5	0.0035
29	p.m.	0.099	0.046	0.15	12.2	0.0018
30	a.m.	0.076	0.036	0.11	19.4	0.0021
31	p.m.	0.073	0.036	0.11	15.8	0.0017
September						
1	a.m.	0.11	0.053	0.16	18.5	0.0030

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Table E-3 Repetitive Counts on D-Day Milk

Cow	Day Counted	nCi/liter*
15	0.44	490
	2.30	330
	4.65	280
	9.20	255
	13.78	155
	19.29	92
	24.00	66
27	0.46	58
	2.29	44
	4.66	36
	9.21	32
	13.79	19
	19.29	12
	24.00	8.3

$t_{\frac{1}{2}}$ = 8.67 days ^{131}I = 79.9%

*Activity in the 0.36 MeV channel

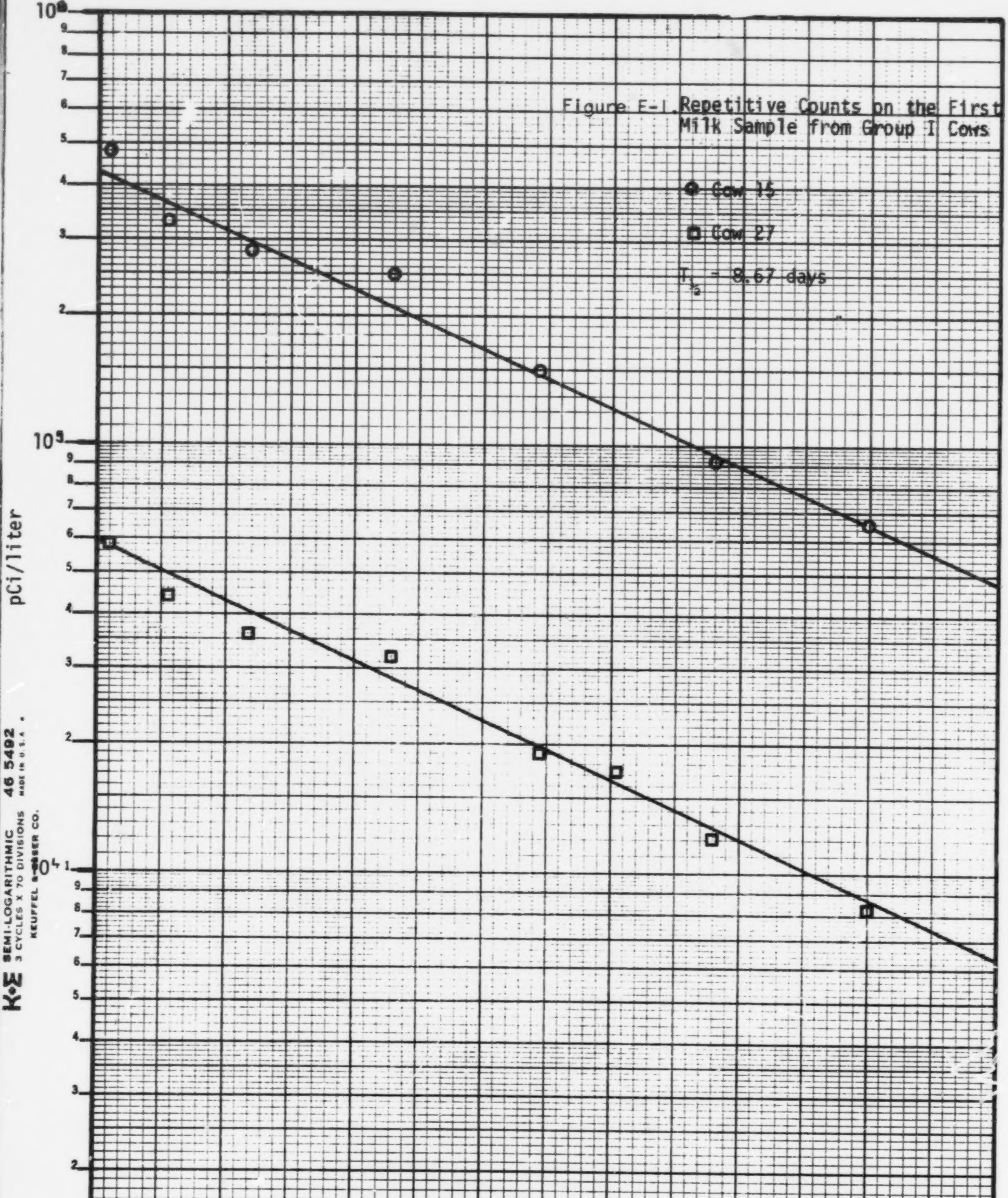

Figure E-1. Repetitive Counts on the First Milk Sample from Group I Cows

APPENDIX E

Table E-4 Radioiodine Results from Ion-exchange Study (ηCi/liter)

Cow 15	Ion-exchange Column			Effluent			Sum
Date	^{131}I	^{126}I	Total	^{131}I	^{126}I	Total	ηCi
August 1965							
12	370	95	460	10	2.6	13	470
13	150	39	190	2.9	0.77	3.7	190
14	40	11	52	1.2	0.32	1.5	54
15	11	3.0	14	0.35	0.10	0.45	14
16	3.6	1.1	4.7	0.16	0.048	0.21	4.9
17	2.1	0.66	2.8	0.11	0.033	0.14	2.9
18	0.75	0.24	0.99	0.092	0.029	0.12	1.1
19	0.42	0.14	0.56			0.050	0.61
20	0.28	0.096	0.38			0.030	0.41
21	0.23	0.079	0.31			0.030	0.34
23	0.24	0.092	0.34			0.030	0.37
24	0.20	0.078	0.28			0.020	0.30
25	0.19	0.075	0.26			0.020	0.28
26	0.16	0.066	0.23			0.020	0.25
27	0.14	0.059	0.20			0.020	0.22
30	0.083	0.039	0.12			0.010	0.13
September							
1	0.094	0.051	0.15			0.010	0.16

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Table E-4 (continued)

Cow 27	Ion-exchange Column			Effluent			Sum
Date	^{131}I	^{126}I	Total	^{131}I	^{126}I	Total	nCi
August 1965							
12	56	15	71	9.5	2.5	12	83
13	20	5.3	25	2.6	0.70	3.3	28
14	9.5	2.7	12	0.70	0.30	1.0	13
15	3.4	0.97	4.3	0.43	0.12	0.55	4.9
16	1.5	0.44	1.9	0.22	0.064	0.28	2.2
17	0.69	0.21	0.90	0.14	0.042	0.18	1.1
18	0.27	0.086	0.36			0.030	0.39
19	0.15	0.050	0.20			0.02	0.22
20	0.10	0.034	0.13			0.010	0.14
24	0.071	0.027	0.099			0.010	0.11
25	0.10	0.041	0.14			0.010	0.15
26	0.095	0.039	0.14			0.010	0.15
27	0.071	0.031	0.10			0.010	0.11
30	0.044	0.021	0.065			ND*	0.065
September							
4	0.071	0.039	0.011			0.010	0.012

*ND = non-detectable

APPENDIX E

Table E-5 Radioiodine Results from Silver-iodide Procedure (ηCi/liter)

Cow 15 Date	Total Beta Activity	Gamma Activity ^{131}I	Gamma Activity ^{126}I	Chemical Yield-%	Total γ Activity
August 1965					
12	250	180	46	86.8	250
13	100	70	19	80.2	110
14	30	20	5.5	83.5	30
15	6.1	------	------	-----	-----
16	2.4	1.2	0.36	81.5	1.8
17	1.2	0.77	0.24	82.0	1.2
18	0.63	0.42	0.13	82.0	0.67
19	0.38	0.21	0.068	74.2	0.36
20	0.20	0.10	0.035	71.6	0.20
21	0.22	0.13	0.044	72.9	0.23
23	0.14	0.067	0.024	66.3	0.14
24	0.17	0.083	0.032	71.8	0.17
25	0.16	0.075	0.030	77.1	0.14
26	0.14	0.077	0.032	73.6	0.15
27	0.093	-------	------	-----	------
30	0.066	0.042	0.020	75.3	0.082
September					
1	0.075	0.051	0.026	91.1	0.085
4	0.069	0.034	0.018	78.9	0.066

APPENDIX E

Table E-5 (continued)

Cow 27 Date	Total Beta Activity	Gamma Activity ^{131}I	 ^{126}I	Chemical Yield-%	Total γ Activity
August 1965					
12	42	29	7.5	94.5	38
13	20	10	2.8	60.5	22
14	7.7	5.0	1.4	84.0	7.6
15	2.2	1.6	0.47	84.5	2.5
16	0.91	0.58	0.17	83.0	0.91
17	0.49	0.40	0.12	90.0	0.58
18	0.23	0.16	0.052	82.0	0.27
19	0.13	0.079	0.026	76.6	0.14
20	0.086	0.027	0.09	75.0	0.048
21	0.11	0.086	0.030	78.4	0.15
23	0.11	0.032	0.012	55.3	0.078
24	0.061	0.024	0.09	69.2	0.048
25	0.090	0.040	0.016	81.3	0.069
26	0.083	0.049	0.020	79.2	0.087
27	0.070	------	-----	----	------
30	0.037	0.08	0.02	71.4	0.014
September					
1	0.056	0.029	0.015	85.0	0.052
4	0.043	0.081	0.044	87.4	0.14

APPENDIX E

Table E-6 Comparison of Radioiodine Results Between Silver-iodide Procedure and Gamma Scan of Cubitainer

Cow 15 Date	nCi/liter Cubitainer	nCi/liter β AgI*	nCi/liter γ AgI	Percent Recovered β AgI	Percent Recovered γ AgI
August 1965					
12	390	250	250	64.1	64.1
13	150	100	110	66.7	73.3
14	38	30	30	78.9	78.9
15	10	6.1	-----	61.0	----
16	3.8	2.4	1.8	63.2	47.4
17	1.6	1.2	1.2	75.0	75.0
18	1.3	0.63	0.67	48.5	51.5
19	0.91	0.38	0.36	41.8	39.6
20	0.48	0.20	0.20	41.7	41.7
21	0.39	0.22	0.23	56.4	59.0
23	0.30	0.14	0.14	46.7	46.6
24	0.24	0.17	0.17	70.8	70.8
25	0.25	0.16	0.14	64.0	56.0
26	0.23	0.14	0.15	60.9	65.2
27	0.23	0.093	-----	40.4	----
30	0.18	0.066	0.082	36.7	45.6
September					
1	0.14	0.075	0.085	53.6	60.7
			Average**	57.1±12.7	58.4±12.7

---

*β AgI is beta count of AgI, γ is gamma count of AgI.

**average ± standard deviation.

APPENDIX E

Table E-6 (continued)

Cow 27	ηCi/liter			Percent Recovered	
Date	Cubitainer	β AgI*	γ AgI	β AgI	γ AgI
August 1965					
12	70	42	38	60.0	54.3
13	21	20	22	95.2	104.8
14	9.4	7.7	7.6	81.9	80.9
15	4.1	2.2	2.5	53.7	61.0
16	1.6	0.91	0.91	56.9	56.9
17	0.79	0.49	0.58	62.0	73.4
18	0.66	0.23	0.27	34.8	40.9
19	0.62	0.13	0.14	21.0	22.6
20	0.30	0.086	0.048	28.7	16.0
21	0.48	0.11	0.15	22.9	31.3
23	0.20	0.11	0.078	55.0	39.0
24	0.20	0.061	0.048	30.5	24.0
25	0.20	0.090	0.069	45.0	34.5
26	0.16	0.083	0.087	51.9	54.4
27	0.19	0.070	-----	36.8	----
30	0.11	0.037	0.014	33.6	12.7
September					
1	0.16	0.056	0.052	35.0	32.5
			Average	47.3±20.3	46.2±25.2

---

*β AgI and γ AgI represent beta and gamma counting, respectively, of the AgI.

**average ± standard deviation.

APPENDIX F

Milk Data for Group II Cows (19 and 21) Received 86.9% ^{131}I + 13.1% ^{126}I.

Table F-1 Cow 19 Radioiodine Results in Milk from Gamma Scan
Table F-2 Cow 21 Radioiodine Results in Milk from Gamma Scan
Table F-3 Repetitive Counts on D-Day Milk
Table F-4 Radioiodine Results from Ion-exchange Study
Table F-5 Radioiodine Results from Silver-iodide Procedure
Table F-6 Comparison of Radioiodine Results Between Silver-iodide Procedure and Gamma Scan of Cubitainer
Figure F-1 Repetitive Counts on the First Milk Sample Procedure and Gamma Scan of Cubitainer

APPENDIX F

Table F-1 Cow 19 Radioiodine Results in Milk from Gamma Scan

Date		ηCi/liter ^{131}I	^{126}I	Sum	Production Liters	Total ^{131}I + ^{126}I μCi
August 1965						
11	p.m.	270	41	310	6.3	2.0
12	a.m.	210	33	240	10.0	2.4
	p.m.	160	24	180	7.2	1.3
13	a.m.	74	12	86	11.3	0.97
	p.m.	46	7.4	53	6.8	0.36
14	a.m.	14	2.3	16	11.8	0.19
	p.m.	9.4	1.6	11	6.8	0.075
15	a.m.	4.2	0.71	4.9	10.9	0.053
	p.m.	2.7	0.47	3.2	7.2	0.023
16	a.m.	1.2	0.21	1.4	11.8	0.017
	p.m.	0.76	0.14	0.90	6.8	0.0061
17	a.m.	0.51	0.094	0.61	10.9	0.0066
	p.m.	0.86	0.16	0.10	6.8	0.0068
18	a.m.	0.58	0.11	0.69	10.8	0.0075
	p.m.	0.81	0.16	0.96	6.3	0.0060
19	a.m.	0.37	0.073	0.45	9.5	0.0043
	p.m.	0.51	0.10	0.61	6.3	0.0038
20	a.m.	0.26	0.053	0.32	10.0	0.0032
	p.m.	0.53	0.11	0.64	6.8	0.0044
21	p.m.	0.48	0.10	0.58	11.8	0.0068

APPENDIX F

Table F-I (continued)

Date		ηCi/liter			Production	Total ^{131}I +
		^{131}I	^{126}I	Sum	Liters	^{126}I µCi
22	a.m.	0.48	0.10	0.58	10.8	0.0063
23	a.m.	0.14	0.031	0.17	10.8	0.0018
	p.m.	0.58	0.13	0.71	6.3	0.0045
24	a.m.	0.25	0.057	0.31	10.4	0.0032
	p.m.	0.97	0.23	1.2	5.4	0.0065
25	a.m.	0.4	0.033	0.17	10.4	0.0018
26	a.m.	0.13	0.033	0.17	9.5	0.0016
27	a.m.	0.12	0.030	0.15	9.9	0.0015
September						
1	a.m.	0.097	0.029	0.13	9.5	0.0012
2	p.m.	0.13	0.040	0.17	6.7	0.0011

APPENDIX F

Table F-2 Cow 21 Radioiodine Results in Milk Gamma Scan

Date		ηCi/liter ^{131}I	^{126}I	Sum	Production Liters	Total ^{131}I + ^{126}I μCi
August 1965						
11	p.m.	340	52	390	7.2	2.8
12	a.m.	300	46	340	12.2	4.1
	p.m.	210	32	240	7.2	1.7
13	a.m.	85	14	99	11.8	1.2
	p.m.	44	7.2	51	10.0	0.51
14	a.m.	23	3.9	27	13.6	0.37
	p.m.	17	0.80	18	7.7	0.14
15	a.m.	8.5	0.15	10	14.0	0.14
	p.m.	6.1	0.11	7.1	10.4	0.074
16	a.m.	2.8	0.49	3.3	14.0	0.046
	p.m.	2.8	0.51	3.3	8.6	0.028
17	a.m.	1.2	0.22	1.4	13.1	0.018
	p.m.	1.5	0.29	1.8	7.7	0.014
18	a.m.	1.0	0.19	1.2	14.0	0.017
	p.m.	0.92	0.18	1.1	8.6	0.0095
19	a.m.	0.50	0.099	0.60	14.0	0.0084
	p.m.	0.48	0.096	0.58	8.6	0.0050
20	a.m.	0.30	0.061	0.36	14.0	0.0050
	p.m.	0.32	0.065	0.38	8.2	0.0031
21	a.m.	0.29	0.062	0.36	14.5	0.0052
	p.m.	0.35	0.074	0.42	8.2	0.0034

APPENDIX F

Table F-2 (continued)

Date		ηCi/liter ^{131}I	^{126}I	Sum	Production Liters	Total ^{131}I + ^{126}I μCi
22	a.m.	0.19	0.040	0.23	13.5	0.0031
	p.m.	0.20	0.043	0.24	7.2	0.0017
23	a.m.	0.19	0.042	0.23	14.0	0.0032
	p.m.	0.23	0.052	0.28	8.6	0.0024
24	a.m.	0.19	0.043	0.23	12.6	0.0029
	p.m.	0.25	0.058	0.31	7.7	0.0024
25	a.m.	0.16	0.039	0.20	14.0	0.0028
	p.m.	0.18	0.043	0.22	8.1	0.0018
26	a.m.	0.17	0.042	0.21	14.0	0.0029
	p.m.	0.15	0.039	0.19	7.2	0.0014
27	a.m.	0.13	0.034	0.17	13.1	0.0022
29	p.m.	0.13	0.035	0.16	6.3	0.0010
30	a.m.	0.11	0.031	0.14	13.1	0.0018
31	p.m.	0.064	0.019	0.084	8.1	0.0068
September						
1	a.m.	0.12	0.037	0.16	10.4	0.0017

APPENDIX F

Table F-3 Repetitive Counts on D-Day Milk

Cow	Day Counted	ηCi/liter*
19	0.47	220
	2.32	170
	4.67	140
	9.28	120
	13.76	72
	23.97	3.3
21	0.46	280
	2.31	180
	4.66	160
	12.08	99
	13.75	80
	19.30	51
	23.97	29

$t_{1/2}$ = 8.34 days ^{131}I = 86.9%

*Activity in the 0.36 MeV channel

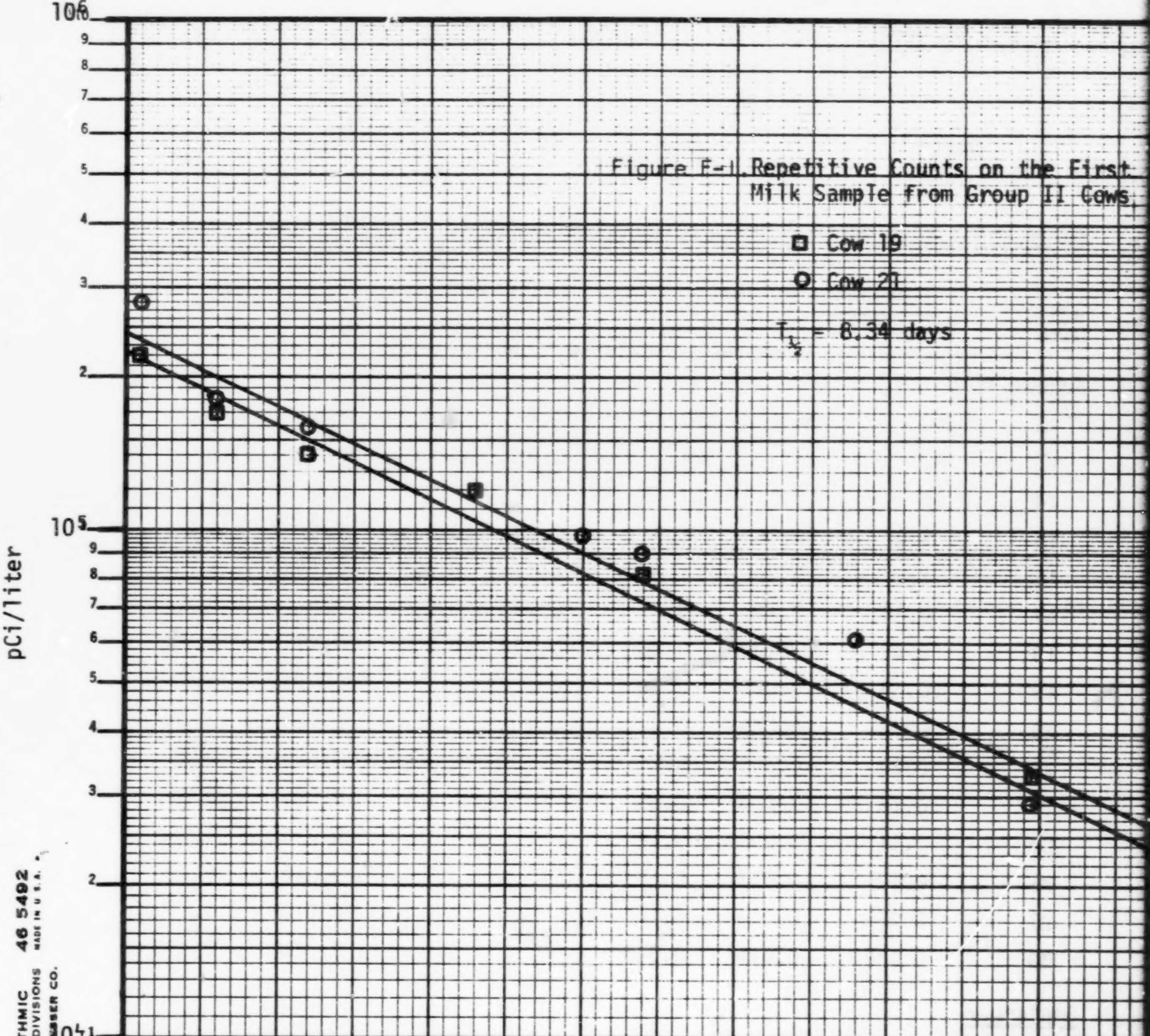

Figure F-1. Repetitive Counts on the First Milk Sample from Group II Cows.

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APPENDIX F

Table F-4 Radioiodine Results from Ion-exchange Study (ηCi/liter)

Cow 19	Ion-exchange Column			Effluent			Sum
Date	^{131}I	^{126}I	Total	^{131}I	^{126}I	Total	ηCi
August 1965							
12	240	38	280	7.7	1.2	8.9	290
13	81	13	94	2.8	0.45	3.3	97
14	18	3.0	21	2.4	0.57	3.0	23
15	5.0	0.86	5.9	0.26	0.045	0.31	6.2
16	1.6	0.28	1.8	0.11	0.020	0.13	1.9
17	0.63	0.12	0.75	0.092	0.017	0.11	0.86
18	0.47	0.090	0.56	0.014	0.027	0.17	0.73
19	0.32	0.063	0.38			0.030	0.41
20	0.18	0.036	0.22			0.020	0.24
21	0.20	0.041	0.24			0.020	0.26
23	0.16	0.035	0.19			0.020	0.21
24	0.11	0.025	0.14			0.010	0.15
26	0.12	0.030	0.15			0.010	0.16
27	0.093	0.024	0.12			0.010	0.13
30	0.038	0.011	0.049			0.010	0.050
September							
3	0.095	0.031	0.013			0.010	0.014

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Table F-4 (continued)

Cow 21	Ion-exchange Column			Effluent			Sum
Date	^{131}I	^{126}I	Total	^{131}I	^{126}I	Total	nCi
August 1965							
12	320	49	370	10	1.6	12	380
13	120	19	140	5.2	0.83	6.0	150
14	33	5.5	39	1.7	0.32	2.0	41
15	11	1.8	13	0.40	0.069	0.47	13
16	3.8	0.67	4.4	0.21	0.037	0.25	4.7
17	1.8	0.34	2.2	0.14	0.025	0.16	2.4
18	0.80	0.15	0.95	0.24	0.045	0.29	1.2
19	0.40	0.078	0.48			0.040	0.52
20	0.24	0.049	0.29			0.020	0.31
21	0.17	0.035	0.20			0.020	0.22
23	0.17	0.039	0.21			0.020	0.23
24	0.14	0.032	0.17			0.010	0.18
25	0.13	0.031	0.16			0.010	0.17
26	0.12	0.029	0.15			0.010	0.16
27	0.12	0.032	0.16			0.010	0.17
30	0.073	0.021	0.094			0.010	0.10
September							
3	0.057	0.019	0.076			ND*	0.080

*ND = non-detectable

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Table F-5 Radioiodine Results from Silver-iodide Procedure (ηCi/liter)

Cow 19 Date	Total Beta Activity	Gamma Activity ^{131}I	 ^{126}I	Chemical Yield-%	Total γ Activity
August 1965					
12	150	120	18	89.4	160
13	44	29	4.7	78.9	43
14	10	62	1.0	78.9	9.1
15	3.5	25	0.42	81.0	3.6
16	0.87	0.61	0.11	80.7	0.89
17	0.44	0.25	0.046	85.2	0.35
18	0.32	0.20	0.038	84.4	0.28
19	0.19	0.11	0.021	75.0	0.17
20	0.13	0.054	0.011	81.5	0.080
21	0.12	0.041	0.09	71.0	0.070
23	0.11	0.068	0.015	78.9	0.11
24	0.090	0.029	0.07	76.5	0.046
25	0.091	0.063	0.015	81.0	0.096
26	0.093	0.060	0.015	80.7	0.093
30	0.042	0.026	0.07	80.0	0.041
September					
1	0.056	0.041	0.012	80.2	0.066
3	0.046	0.027	0.09	74.4	0.048

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Table F-5 (continued)

Cow 21 Date	Total Beta Activity	Gamma Activity ^{131}I	 ^{126}I	Chemical Yield-%	Total γ Activity
August 1965					
12	210	140	22	90.0	180
13	63	43	6.9	78.9	63
14	18	11	1.9	77.6	1.7
15	7.6	5.9	1.0	92.3	7.4
16	2.7	1.9	0.34	87.1	2.6
17	1.1	0.91	0.17	93.4	1.2
18	0.63	0.40	0.075	82.1	0.58
20	0.17	0.071	0.014	76.3	0.11
21	0.17	0.098	0.020	79.2	0.15
23	0.17	0.11	0.025	78.9	0.17
24	0.10	0.044	0.010	73.1	0.074
25	0.10	0.085	0.020	86.5	0.12
26	0.093	0.050	0.012	78.9	0.078
27	0.067	-------	------	81.3	-------
30	0.047	0.023	0.07	77.1	0.038
September					
1	0.055	0.041	0.012	89.4	0.059
2	0.044	0.022	0.07	73.6	0.039

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Table F-6 Comparison of Radioiodine Results Between Silver-iodide Procedure and Gamma Scan of Cubitainer

Cow 19	nCi/liter			Percent Recovered	
Date	Cubitainer	β AgI*	γ AgI	β AgI	γ AgI
August 1965					
12	240	150	160	62.5	66.7
13	86	44	43	51.2	50.0
14	16	10	9.1	62.5	56.9
15	4.9	3.5	3.6	71.4	73.5
16	1.4	0.87	0.89	62.1	63.6
17	0.61	0.44	0.35	72.1	57.4
18	0.69	0.32	0.28	46.4	40.6
19	0.45	0.19	0.17	42.2	37.8
20	0.32	0.13	0.080	40.6	25.0
23	0.17	0.11	0.11	64.7	64.7
24	0.31	0.090	0.046	29.0	14.8
25	0.17	0.091	0.096	53.5	56.5
26	0.17	0.093	0.093	54.7	54.7
September					
1	0.13	0.056	0.066	43.1	50.8
			Average**	54.0±12.7*	50.9±16.4

---

*β AgI and γ AgI are beta and gamma counts of the AgI.

**average ± standard deviation.

APPENDIX F

Table F-6 (continued)

Cow 21	ηCi/liter			Percent Recovered	
Date	Cubitainer	β AgI*	γ AgI	β AgI	γ AgI
August 1965					
12	340	210	180	61.8	52.9
13	99	63	63	63.6	63.6
14	27	18	17	66.7	63.0
15	10	7.6	7.4	76.0	74.0
16	3.3	2.7	2.6	81.8	78.8
17	1.4	1.1	1.2	78.6	85.7
18	1.2	0.63	0.58	52.5	48.3
20	0.36	0.17	0.58	52.5	30.6
21	0.36	0.17	0.15	47.2	41.7
23	0.23	0.17	0.17	73.9	73.9
24	0.23	0.10	0.074	43.5	32.2
25	0.20	0.10	0.12	50.0	60.0
26	0.21	0.093	0.078	44.3	37.1
27	0.17	0.067	-----	39.4	----
30	0.14	0.047	0.038	33.6	27.1
September					
1	0.16	0.055	0.059	34.4	36.9
			Average**	55.9±16.0	53.7±19.2

---

*β AgI and γ AgI are beta and gamma counts of the AgI.

**average ± standard deviation.

APPENDIX G

Milk Data for Group III Cows (18 and 25) Received 93.0% ^{131}I + 7.0% ^{126}I.

Table G-1 Cow 18 Radioiodine Results in Milk from Gamma Scan

Table G-2 Cow 25 Radioiodine Results in Milk from Gamma Scan

Table G-3 Repetitive Counts on D-Day Milk

Table G-4 Radioiodine Results from Ion-exchange Study

Table G-5 Radioiodine Results from Silver-iodide Procedure

Table G-6 Comparison of Radioiodine Results Between Silver-iodide Procedure and Gamma Scan of Cubitainer

Figure G-1 Repetitive Counts on the First Milk Sample From Group III Cows

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Table G-1 Cow 18 Radioiodine Results in Milk from Gamma Scan

Date		ηCi/liter			Production Liters	Total ^{131}I + ^{126}I µCi
		^{131}I	^{126}I	Sum		
August 1965						
11	p.m.	560	64	620	5.9	3.7
12	a.m.	360	42	410	9.5	3.8
	p.m.	280	33	310	5.4	1.7
13	a.m.	92	11	100	11.3	1.1
	p.m.	47	5.8	53	6.8	0.36
14	a.m.	24	3.0	27	10.9	0.29
	p.m.	16	2.0	18	5.4	0.097
15	a.m.	6.3	0.82	7.1	11.3	0.080
	p.m.	3.9	0.52	4.5	6.8	0.031
16	a.m.	1.9	0.25	2.1	11.3	0.024
	p.m.	1.6	0.21	1.8	5.9	0.011
17	a.m.	1.1	0.15	1.2	10.4	0.012
	p.m.	1.4	0.20	1.6	5.4	0.0086
18	a.m.	1.0	0.15	1.2	7.7	0.0092
	p.m.	1.1	0.16	1.3	8.2	0.011
19	a.m.	0.75	1.1	0.86	7.7	0.0066
	p.m.	1.1	0.16	1.2	7.2	0.0086
20	a.m.	0.55	0.084	0.64	10.0	0.0064
	p.m.	0.82	0.13	0.94	6.8	0.0064
22	a.m.	0.86	0.14	1.0	9.9	0.0099
	p.m.	0.74	0.12	0.87	5.8	0.0050

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Table G-I (continued)

Date		nCi/liter			Production	Total ^{131}I +
		^{131}I	^{126}I	Sum	Liters	^{126}I μCi
August 1965						
23	a.m.	0.34	0.057	0.39	9.9	0.0039
	p.m.	0.87	0.15	1.0	5.4	0.0059
24	a.m.	0.38	0.060	0.44	11.3	0.0050
	p.m.	0.81	0.14	0.95	5.4	0.0051
25	a.m.	0.28	0.051	0.33	9.9	0.0033
26	a.m.	0.26	0.049	0.31	10.4	0.0032
27	a.m.	0.19	0.037	0.23	10.8	0.0025
30	a.m.	0.15	0.032	0.18	9.5	0.0017
31	p.m.	0.15	0.032	0.18	7.2	0.0013
September						
1	a.m.	0.14	0.031	0.17	8.6	0.0015
2	p.m.	0.13	0.032	0.17	5.8	0.0010

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Table G-2 Cow 25 Radioiodine Results in Milk from Gamma Scan

Date		ηCi/liter			Production Liters	Total ^{131}I + ^{126}I µCi
		^{131}I	^{126}I	Sum		
August 1965						
11	p.m.	160	19	180	13.1	2.4
12	a.m.	90	11	100	19.5	2.0
	p.m.	74	8.7	83	13.1	1.1
13	a.m.	41	5.0	46	18.6	0.86
	p.m.	24	2.9	27	13.6	0.37
14	a.m.	16	2.0	18	20.4	0.37
	p.m.	11	1.4	12	15.4	0.18
15	a.m.	4.5	0.58	5.0	23.1	0.12
	p.m.	3.7	0.48	4.2	14.0	0.059
16	a.m.	2.3	0.30	2.6	23.1	0.053
	p.m.	0.58	0.078	0.66	14.9	0.0098
17	a.m.	1.3	0.17	1.4	17.2	0.024
	p.m.	1.3	0.18	1.5	14.5	0.022
18	a.m.	0.84	0.12	0.96	23.6	0.023
	p.m.	0.86	0.12	0.98	14.0	0.014
19	a.m.	0.53	0.078	0.60	23.6	0.014
	p.m.	0.49	0.073	0.57	14.0	0.0080
20	a.m.	0.40	0.061	0.46	23.1	0.011
	p.m.	0.27	0.042	0.31	16.3	0.0051
21	a.m.	0.16	0.025	0.18	23.6	0.0042
	p.m.	0.49	0.078	0.57	13.6	0.0078

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Table G-2 (continued)

Date		nCi/liter ^{131}I	^{126}I	Sum	Production Liters	Total ^{131}I + ^{126}I µCi
22	a.m.	0.28	0.046	0.33	24.0	0.0079
	p.m.	0.21	0.035	0.25	13.1	0.0033
23	a.m.	0.20	0.034	0.23	20.3	0.0047
	p.m.	0.16	0.028	0.19	13.1	0.0025
24	a.m.	0.31	0.053	0.36	21.7	0.0078
	p.m.	0.22	0.039	0.26	14.9	0.0039
25	a.m.	0.23	0.041	0.27	21.2	0.0057
	p.m.	0.25	0.045	0.29	14.9	0.0043
26	a.m.	0.23	0.044	0.28	21.7	0.0061
	p.m.	0.18	0.034	0.22	13.4	0.0029
27	a.m.	0.22	0.043	0.27	24.9	0.0067
	p.m.	0.19	0.037	0.23	13.1	0.0030
29	p.m.	0.22	0.046	0.27	12.6	0.0034
30	a.m.	0.15	0.032	0.18	20.3	0.0037
31	p.m.	0.092	0.020	0.11	15.4	0.0017
September						
1	a.m.	0.12	0.026	0.14	20.3	0.0028

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Table G-3 Repetitive Counts on D-Day Milk

Cow	Day Counted	ηCi/liter*
18	0.50	450
	2.32	320
	4.67	250
	9.29	220
	13.77	130
	23.96	51
25	0.55	130
	2.35	92
	4.67	73
	9.30	63
	13.77	35
	19.32	24
	23.95	16

$t_{1/2}$ = 8.05 days ^{131}I = 93.0%

*Activity in the 0.36 MeV channel

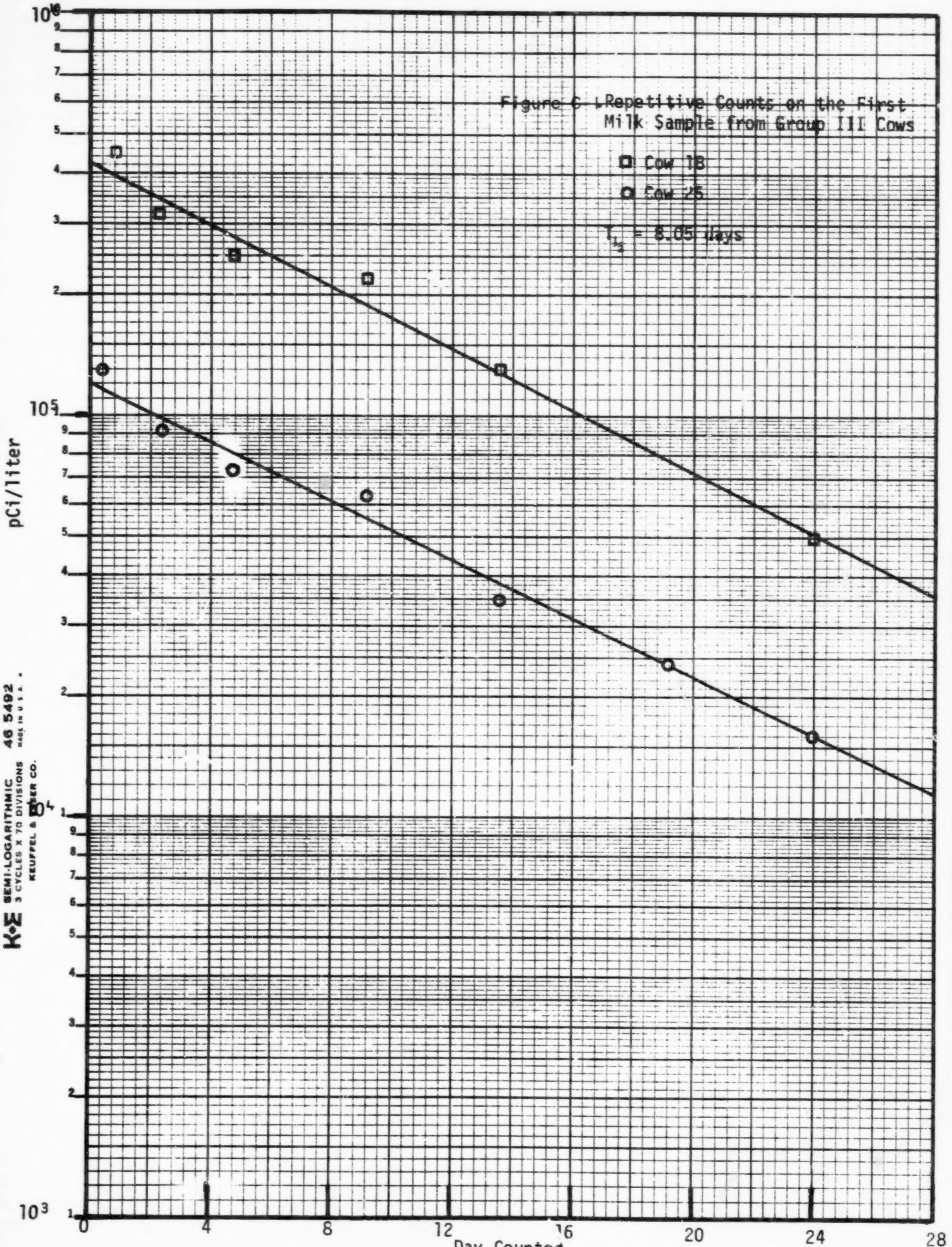

Figure 6 Repetitive Counts on the First Milk Sample from Group III Cows

APPENDIX G

Table G-4 Radioiodine Results from Ion-exchange Study (ηCi/liter)

Cow 18	Ion-exchange Column			Effluent			Sum
Date	^{131}I	^{126}I	Total	^{131}I	^{126}I	Total	ηCi
August 1965							
12	430	50	480	35	4.9	40	520
13	120	14	130	8.5	1.5	10	140
14	31	3.9	35	2.6	0.36	3.0	38
15	9.5	1.2	11	0.88	0.12	1.0	12
16	3.0	0.40	3.4	0.17	0.023	1.9	3.6
17	1.4	0.19	1.6	0.12	0.016	1.4	1.7
18	0.91	0.13	1.0	0.072	0.010	0.082	1.1
19	0.69	0.10	0.79			0.070	0.86
20	0.42	0.063	0.48			0.040	0.52
21	0.35	0.054	0.40			0.030	0.43
23	0.15	0.025	0.17			0.010	0.18
24	0.34	0.060	0.40			0.030	0.43
25	0.26	0.046	0.30			0.030	0.33
26	0.24	0.045	0.29			0.020	0.31
27	0.20	0.038	0.23			0.020	0.25
30	0.064	0.014	0.078			0.010	0.090
September							
3	0.069	0.017	0.087			ND*	0.090

*ND = non-detectable

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Table G-4 (continued)

Cow 25 Date	Ion-exchange Column ^{131}I	 ^{126}I	 Total	Effluent ^{131}I	 ^{126}I	 Total	Sum ηCi
August 1965							
12	120	14	130	10	1.2	11	140
13	49	5.9	55	4.2	0.50	4.7	60
14	19	2.4	21	2.7	0.34	3.0	24
15	6.9	0.89	7.7	0.24	0.031	0.27	8.0
16	3.0	0.41	3.4	0.16	0.021	0.18	3.6
17	0.69	0.095	0.79	0.078	0.010	0.090	0.88
18	0.67	0.096	0.77	0.25	0.035	0.28	1.1
19	0.44	0.065	0.51			0.040	0.55
20	0.28	0.042	0.32			0.030	0.35
21	0.17	0.027	0.20			0.020	0.22
23	0.35	0.060	0.41			0.040	0.45
24	0.21	0.037	0.25			0.020	0.27
25	0.19	0.034	0.22			0.020	0.24
26	0.15	0.0 8	0.18			0.020	0.20
27	0.15	0.029	0.18			0.020	0.20
30	0.12	0.025	0.14			0.010	0.15
September							
3	0.11	0.026	0.13			0.010	0.14

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Table G-5 Radioiodine Results from Silver-iodide Procedure (ηCi/liter)

Cow 18 Date	Total Beta Activity	Gamma Activity ^{131}I	 ^{126}I	Chemical Yield-%	Total γ Activity
August 1965					
12	300	190	22	84.7	250
13	65	47	5.7	79.2	67
14	18	12	1.5	75.2	19
15	7.2	5.9	0.76	92.1	7.3
16	1.9	1.5	0.20	87.3	1.9
17	0.92	0.61	0.084	84.2	0.82
18	0.62	0.47	0.066	92.8	0.57
19	0.47	0.30	0.044	80.2	0.42
20	0.27	0.21	0.032	85.5	0.28
21	0.23	0.15	0.023	67.6	0.25
23	0.26	0.20	0.034	76.3	0.30
24	0.20	0.12	0.020	78.9	0.18
25	0.18	0.11	0.019	76.5	0.16
26	0.18	0.11	0.021	83.6	0.16
27	0.13	------	------	83.9	------
30	0.063	0.035	0.010	72.6	0.059
September					
1	0.092	0.044	0.010	73.9	0.073
3	0.066	0.051	0.012	82.8	0.076

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Table G-5 (continued)

Cow 25 Date	Total Beta Activity	Gamma Activity		Chemical Yield-%	Total γ Activity
		^{131}I	^{126}I		
August 1965					
12	78	46	5.4	79.2	64
13	------	17	2.1	76.5	25
14	13	9.0	1.1	83.6	12
15	4.2	3.9	0.50	94.2	4.7
16	1.9	1.6	0.22	91.3	2.0
17	1.2	0.93	0.13	92.6	1.2
18	0.43	0.29	0.041	82.1	0.40
20	0.19	0.13	0.019	92.1	0.16
21	0.21	0.15	0.024	80.5	0.21
23	0.16	0.11	0.019	82.1	0.16
24	0.14	0.12	0.020	75.7	0.18
25	0.11	0.085	0.015	74.2	0.13
26	0.12	0.077	0.014	79.7	0.11
27	0.12	------	-----	84.2	-----
30	0.068	0.050	0.011	82.8	0.074
September					
1	0.049	0.028	0.010	84.4	0.040
3	0.054	0.057	0.014	88.9	0.080

APPENDIX G

Table G-6 Comparison of Radioiodine Results Between Silver-iodine Procedure and Gamma Scan of Cubitainer

Cow 18		nCi/liter		Percent Recovered	
Date	Cubitainer	β AgI*	γ AgI	β AgI	γ AgI
August 1965					
12	410	300	250	73.2	61.0
13	100	65	67	65.0	67.0
14	27	18	19	66.7	70.4
15	7.1	7.2	7.3	101.4	102.8
16	2.1	1.9	1.9	90.5	90.5
17	1.2	0.92	0.82	76.7	68.3
18	1.2	0.62	0.57	51.7	47.5
19	0.86	0.47	0.42	54.7	48.8
20	0.64	0.27	0.28	42.2	43.8
23	0.39	0.26	0.30	66.7	76.9
24	0.44	0.20	0.18	45.5	40.9
25	0.33	0.18	0.16	54.5	48.5
26	0.31	0.18	0.16	58.1	51.6
27	0.23	0.13	----	56.5	----
30	0.18	0.063	0.059	35.0	32.8
September					
1	0.17	0.092	0.073	54.1	42.9
			Average**	62.0±17.3	59.6±19.7

---

*β AgI and γ AgI are beta and gamma counts of the AgI.

**average ± standard deviation.

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Table G-6 (continued)

Cow 25 Date		ηCi/liter		Percent Recovered	
	Cubitainer	β AgI*	γ AgI	β AgI	γ AgI
August 1965					
12	100	78	64	78.0	64.0
13	46	------	25	----	54.3
14	18	13	12	72.2	66.7
15	5.0	4.2	4.7	84.0	94.0
16	2.6	1.9	2.0	73.1	76.9
17	1.4	1.2	1.2	85.7	85.7
18	0.96	0.43	0.40	44.8	41.7
20	0.46	0.19	0.16	41.3	34.8
21	0.18	0.21	0.21	116.7	116.7
23	0.23	0.16	0.16	69.6	69.6
24	0.36	0.14	0.18	38.9	50.0
25	0.27	0.11	0.13	40.7	48.1
26	0.28	0.12	0.11	42.9	39.3
27	0.27	0.12	----	44.4	----
30	0.18	0.068	0.074	37.8	41.1
September					
1	0.14	0.049	0.040	35.0	28.6
			Average**	60.3±24.3	60.8±24.6

---

*β AgI and γ AgI are beta and gamma counts of the AgI.

**average ± standard deviation.

APPENDIX H

Milk Data for Group IV Cows (12 and 28) Received 100.0% ^{131}I.

Table H-1 Cow 12 Radioiodine Results in Milk from Gamma Scan

Table H-2 Cow 28 Radioiodine Results in Milk from Gamma Scan

Table H-3 Repetitive Counts on D-Day Milk

Table H-4 Radioiodine Results from Ion-exchange Study

Table H-5 Radioiodine Results from Silver-iodide Procedure

Table H-6 Comparison of Radioiodine Results Between Silver-iodide Procedure and Gamma Scan of Cubitainer

Figure H-1 Repetitive Counts on the First Milk Sample From Group IV Cows

APPENDIX H

TABLE H-1 Cow 12 Radioiodine Results in Milk from Gamma Scan

Date		^{131}I nCi/liter	Production Liters	Total ^{131}I µCi
August 1965				
11	p.m.	1700	6.8	12
12	a.m.	980	7.7	7.5
	p.m.	700	6.3	4.4
13	a.m.	140	8.6	1.2
	p.m.	99	6.3	0.62
14	a.m.	41	10.0	0.41
	p.m.	20	6.8	0.14
15	a.m.	8.2	10.0	0.082
	p.m.	5.1	5.4	0.028
16	a.m.	2.8	10.9	0.031
	p.m.	2.4	7.2	0.017
17	a.m.	1.5	8.6	0.013
	p.m.	1.9	5.9	0.011
18	a.m.	2.2	7.7	0.017
	p.m.	2.0	17.7	0.035
19	a.m.	1.1	7.7	0.085
	p.m.	2.0	6.8	0.014
20	a.m.	1.3	9.5	0.012
	p.m.	1.4	5.4	0.0076
21	a.m.	7.8	8.2	0.0064
	p.m.	1.4	6.3	0.088

APPENDIX H

Table H-I (continued)

Date		^{131}I ηCi/liter	Production Liters	Total ^{131}I µCi
23	a.m.	0.61	9.0	0.0055
	p.m.	1.1	6.7	0.0074
24	a.m.	0.54	8.1	0.0044
	p.m.	0.76	6.7	0.0051
25	a.m.	0.52	9.5	0.0049
26	a.m.	0.44	9.9	0.0044
27	a.m.	0.40	10.4	0.0042
29	p.m.	0.14	6.7	0.0094
30	a.m.	0.27	8.6	0.0023
31	p.m.	0.25	5.8	0.0015
September				
1	a.m.	0.14	7.7	0.0011

APPENDIX H

Table H-2 Cow 28 Radioiodine Results in Milk from Gamma Scan

Date		^{131}I nCi/liter	Production Liters	Total ^{131}I µCi
August 1965				
11	p.m.	490	10.4	5.1
12	a.m.	300	14.9	4.5
	p.m.	190	10.4	2.0
13	a.m.	70	15.9	1.1
	p.m.	36	10.9	0.39
14	a.m.	18	16.8	0.30
	p.m.	10	10.9	0.11
15	a.m.	4.8	18.6	0.089
	p.m.	2.8	11.3	0.032
16	a.m.	1.2	17.7	0.021
	p.m.	0.98	11.3	0.011
17	a.m.	0.82	13.6	0.011
	p.m.	0.83	12.7	0.011
18	a.m.	0.56	16.8	0.0094
	p.m.	0.89	10.9	0.0097
19	a.m.	0.44	16.8	0.0074
	p.m.	0.48	10.9	0.0052
20	a.m.	0.34	17.2	0.0058
	p.m.	0.26	11.3	0.0029
21	a.m.	0.29	16.7	0.0048
	p.m.	0.27	10.4	0.0028

APPENDIX H

Table H-2 (continued)

Date		^{131}I ηCi/liter	Production Liters	Total ^{131}I µCi
22	a.m.	0.16	18.5	0.0030
	p.m.	0.23	9.0	0.0021
23	a.m.	0.24	17.2	0.0041
	p.m.	0.25	9.0	0.0023
24	a.m.	0.20	16.3	0.0034
25	a.m.	0.21	17.2	0.0036
	p.m.	0.20	9.9	0.0020
26	a.m.	0.15	16.7	0.0025
	p.m.	0.20	9.5	0.0019
27	a.m.	0.16	17.6	0.0028
30	a.m.	0.11	16.7	0.0018
31	p.m.	0.11	10.8	0.0012
September				
1	a.m.	0.13	14.0	0.0018

APPENDIX H

Table H-3 Repetitive Counts on D-Day Milk

Cow	Day Counted	μCi/liter*
12	0.55	1.3
	2.36	0.80
	4.68	0.77
	9.30	0.64
	13.75	0.35
	19.33	0.24
	24.20	0.14
28	0.56	0.38
	2.37	0.25
	4.68	0.28
	9.31	0.18
	13.75	0.10
	19.33	0.065
	23.94	0.043

$t_{\frac{1}{2}}$ = 7.81 days ^{131}I = 100%

*Activity in the 0.36 MeV channel

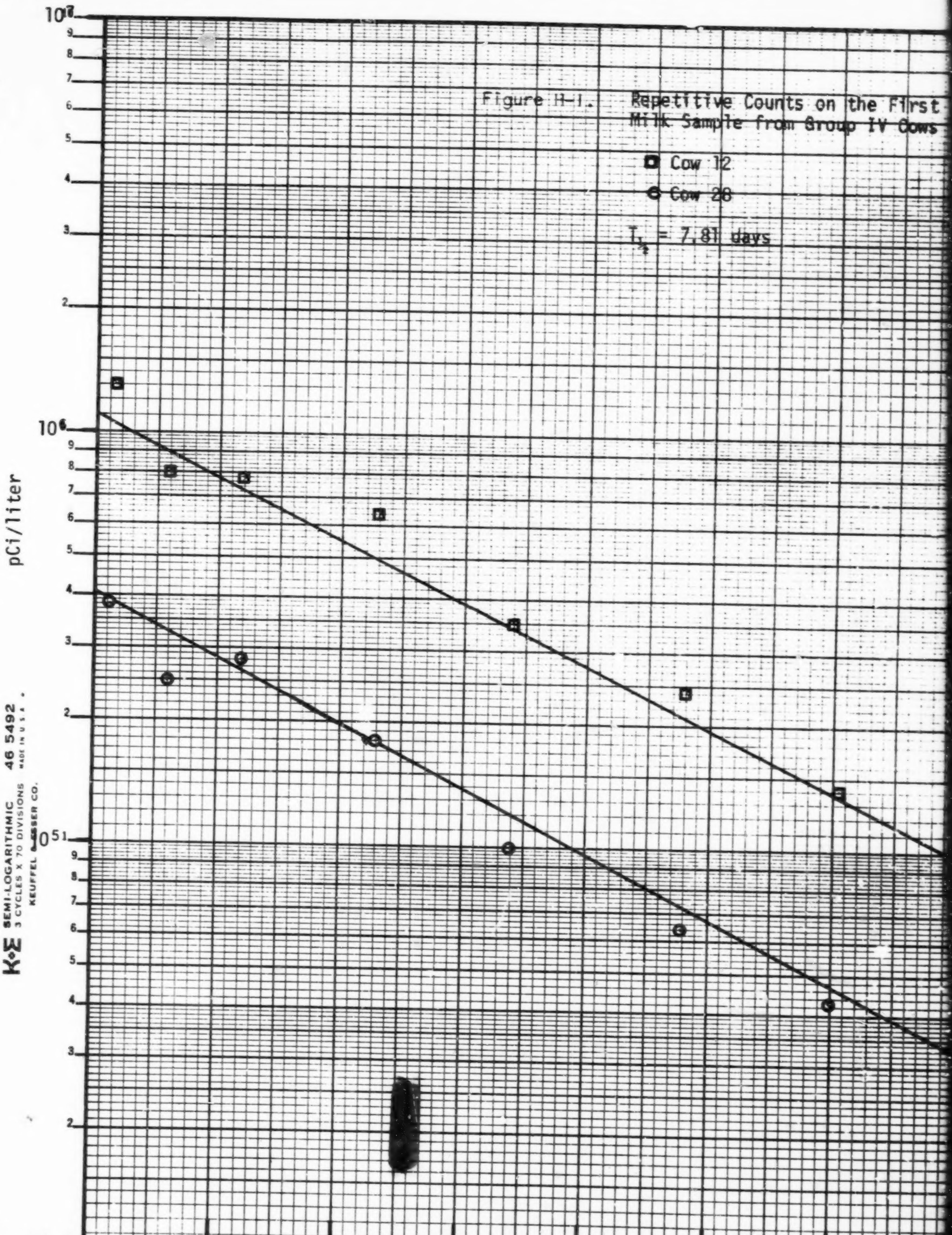

Figure H-1. Repetitive Counts on the First Milk Sample from Group IV Cows

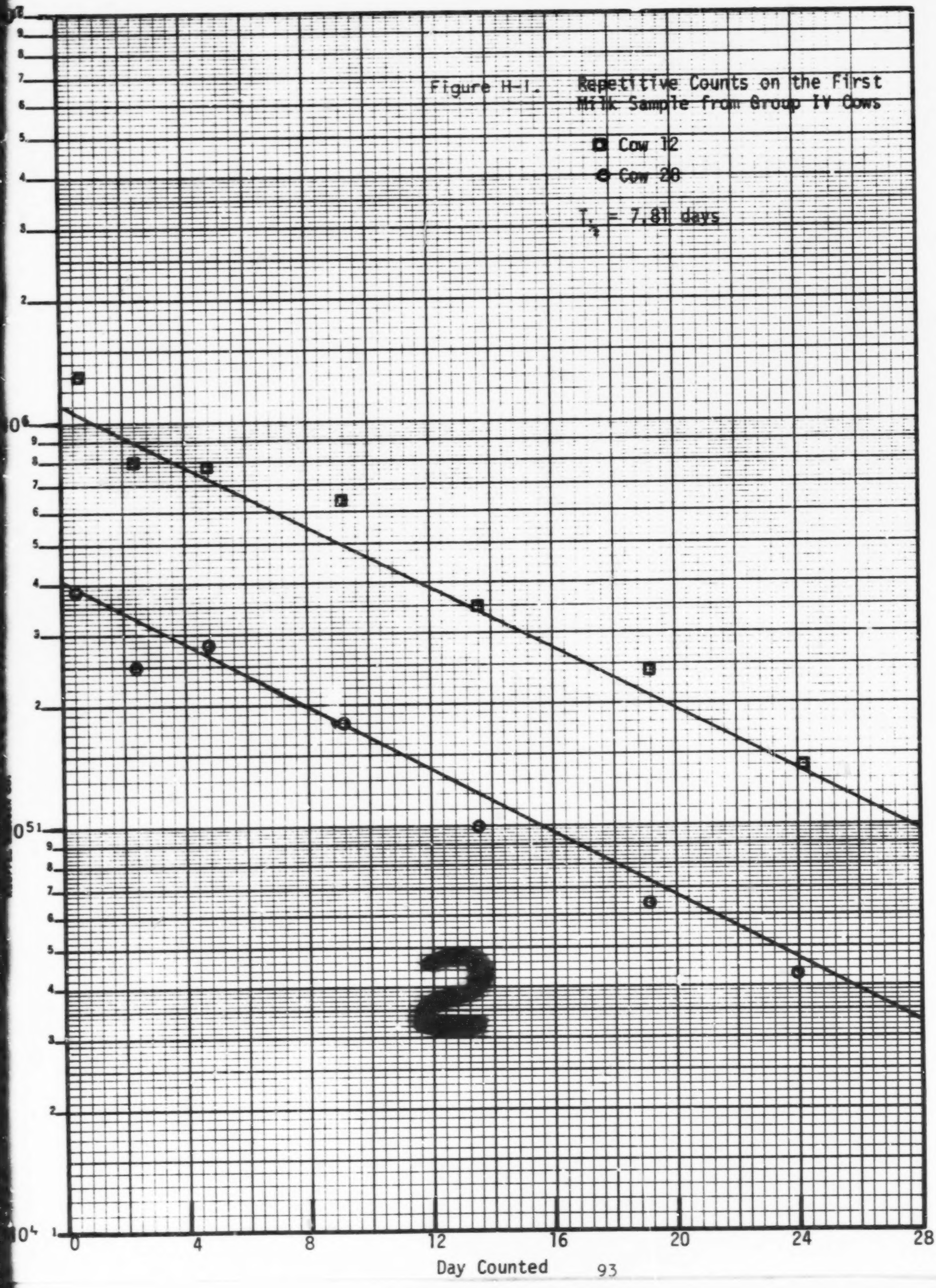

Figure H-1. Repetitive Counts on the First Milk Sample from Group IV Cows

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APPENDIX H

Table H-4 Radioiodine Results from Ion-exchange Study (ηCi/liter)

Cow 12 Date	Resin ^{131}I	Effluent ^{131}I	Total ηCi
August 1965			
12	1100	59	1100
13	260	5.6	270
14	46	3.9	50
15	10	0.41	11
16	4.0	0.24	4.2
17	1.8	0.20	2.0
18	1.9	0.19	2.1
19	1.8	0.19	2.0
20	1.2	0.12	1.3
21	0.73	0.060	0.79
23	0.62	0.050	0.67
24	0.73	0.060	0.79
25	0.54	0.050	0.59
26	0.42	0.040	0.46
27	0.37	0.030	0.40
30	0.29	0.020	0.31
September			
3	0.18	0.010	0.19

APPENDIX H

Table H-4 (continued)

Cow 28 Date	Resin ^{131}I	Effluent ^{131}I	Total nCi
August 1965			
12	380	11	390
13	93	3.0	96
14	23	0.97	24
15	7.5	0.25	7.8
16	1.9	0.14	2.1
17	1.5	0.10	1.6
18	0.56	0.055	0.61
19	0.37	0.030	0.40
20	0.25	0.020	0.27
21	0.15	0.010	0.16
23	0.25	0.020	0.27
24	0.24	0.020	0.26
25	0.15	0.010	0.16
26	0.13	0.010	0.14
27	0.14	0.010	0.15
30	0.10	0.010	0.11
September			
3	0.059		0.060

APPENDIX H

Table H-5 Radioiodine Results from Silver-iodide Procedure (ηCi/liter)

Cow 12 Date	Total Beta Activity	Gamma Activity ^{131}I	Chemical Yield-%	Total γ Activity
August 1965				
12	530	730	86.8	840
13	130	140	79.7	180
14	23	14	82.3	17
15	6.3	7.6	93.8	8.1
16	2.3	3.1	93.9	3.3
17	1.2	1.1	84.6	1.3
18	1.1	1.2	85.7	1.4
19	0.97	-----	----	-----
20	0.53	-----	----	-----
21	0.49	0.48	78.7	0.61
23	0.39	0.16	88.8	0.18
24	0.32	0.23	76.6	0.30
25	0.27	0.26	76.4	0.34
26	0.26	0.29	90.6	0.32
27	0.20	------	----	------
30	0.13	0.14	82.3	0.17
31	0.12	------	----	------
September				
3	0.11	0.15	100.0	0.15

APPENDIX H

Table H-5 (continued)

Cow 28 Date	Total Beta Activity	Gamma Activity ^{131}I	Chemical Yield-%	Total γ Activity
August 1965				
12	220	250	89.5	280
13	39	34	73.6	46
14	12	13	83.9	15
15	4.7	6.2	98.4	6.3
16	1.1	1.2	92.3	1.3
17	0.40	0.47	100.0	0.47
18	0.30	0.22	88.0	0.25
19	0.22	------	----	------
20	0.15	------	----	------
21	0.13	0.15	75.0	0.20
23	0.17	0.14	87.5	0.16
24	0.10	0.093	77.5	0.12
25	0.084	0.010	76.9	0.010
26	0.085	0.10	90.9	0.11
27	0.089	------	----	------
30	0.036	0.020	84.2	0.020
September				
1	0.043	0.068	91.8	0.074
3	0.041	0.063	75.9	0.083

Table H-6 Comparison of Radioiodine Results Between Silver-Iodide Procedure and Gamma Scan of Cubitainer

Cow 12		ηCi/liter		Percent Recovered	
Date	Cubitainer	β AgI*	γ AgI	β AgI	γ AgI
August 1965					
12	980	530	840	54.1	85.7
13	140	130	180	92.8	128.6
14	41	23	17	56.1	41.5
15	8.2	6.3	8.1	76.8	98.8
16	2.8	2.3	3.3	82.1	117.9
17	1.5	1.2	1.3	80.0	86.7
18	2.2	1.1	1.4	50.0	63.6
19	1.1	0.97	-----	88.2	----
20	1.3	0.53	-----	40.8	----
21	0.78	0.49	0.61	62.8	78.2
23	0.61	0.39	0.18	63.9	29.5
24	0.54	0.32	0.30	59.3	55.6
25	0.52	0.27	0.34	51.9	65.4
26	0.44	0.26	0.32	59.1	72.7
27	0.40	0.20	------	50.0	----
30	0.27	0.13	0.17	48.1	63.0
31	0.25	0.12	------	48.0	----
			average**	62.6±15.6	75.9±28.1

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*β AgI and γ AgI are beta and gamma counts of the AgI.

**average ± standard deviation.

APPENDIX H

Table H-6 (continued)

Cow 28	nCi/liter			Percent Recovered	
Date	Cubitainer	β AgI*	γ AgI	β AgI	γ AgI
August 1965					
12	300	220	280	73.3	93.3
13	70	39	46	55.7	65.7
14	18	12	15	66.7	83.3
15	4.8	4.7	6.3	97.9	131.3
16	1.2	1.1	1.3	91.7	108.3
17	0.82	0.40	0.47	48.8	57.3
18	0.56	0.30	0.25	53.6	44.6
19	0.44	0.22	------	50.0	----
20	0.34	0.15	------	44.1	----
21	0.29	0.13	0.20	44.8	69.0
23	0.24	0.17	0.16	70.8	66.7
24	0.21	0.10	0.12	47.6	57.1
25	0.21	0.084	0.013	40.0	6.2
26	0.15	0.085	0.11	56.7	73.3
27	0.16	0.089	------	55.6	----
30	0.11	0.036	0.20	32.7	17.3
September					
1	0.13	0.043	0.074	33.1	56.9
			average**	56.6±18.4	66.4±32.6

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*β AgI and γ AgI are beta and gamma counts of the AgI.

**average ± standard deviation.

APPENDIX I

Half-lives (Days) as Determined from Beta Decay of AgI Precipitates

Date	Group I Cows		Group II Cows		Group III Cows		Group IV Cows	
	15	27	19	21	18	25	12	28
August 1965								
12	8.5	9.5	8.4	9.0	8.0	8.0	8.5	8.2
13	9.0	9.5	8.7	8.5	8.0	7.5	6.2	8.0
14	8.7	8.5	9.2	9.0	9.0	8.0	7.7	8.5
15	8.5	8.2	8.0	8.0	8.0	8.0	9.0	8.0
16	9.2	8.2	8.5	9.0	7.5	8.0	8.2	9.0
17	8.7	9.2	9.0	9.0	8.7	9.0	8.0	9.0
18	8.5	9.0	8.5	6.7	9.0	9.0	8.0	8.0
19	8.7	12.0	10.0	---	9.0	---	8.2	8.5
20	8.2	13.0	9.0	9.0	8.7	9.0	8.2	7.5
21	9.5	11.5	11.0	9.5	8.5	9.2	8.7	10.5
23	10.2	9.0	11.5	10.0	10.2	10.7	8.0	9.2
24	10.0	13.0	10.0	10.7	9.2	9.0	9.0	9.5
25	9.2	10.0	8.5	10.0	9.7	10.0	8.2	9.2
26	9.0	7.0	7.0	9.2	9.0	9.0	9.5	9.0
27	10.0	9.0	8.0	10.0	8.0	8.7	7.7	7.0
Av	9.6	9.77	9.02	9.11	8.70	8.79	8.21	8.61
Std. Dev.	0.6	1.8	1.2	1.0	0.7	0.9	0.8	0.9
Group Av	9.42		9.07		8.74		8.41	
Std. Dev.	1.37		1.07		0.78		0.82	